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Flight Duration, Airspeed Practices, and Altitude Management of Airplanes Involved in the NASA VGH General Aviation Program

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INTRODUCTION

From the beginning of the NASA VGH General Aviation Program in the early 1960's until its termination in 1982, statistical data were collected from general aviation airplanes by means of NASA VGH recorders (ref. 1). The intent of the program was to update information on gust and maneuver accelerations, and also on the operating practices of present-day general aviation airplanes. To accomplish this, care was taken to install the VGH recorders (on a voluntary basis) on airplanes involved in operations typical of modern usage. Upon termination of the program, 42 155 hr of VGH data had been collected from 105 airplanes flown in 9 types of operations: twin-engine executive, single-engine executive, personal, instructional, commercial survey, aerial application, aerobatic, commuter, and float operations. Of these data, 35 286 hr from 95 airplanes were evaluated. Tabulations of gust and maneuver accelerations in 0.1g intervals and of derived gust velocities in 4-ft/sec intervals are given in reference 2 for each of the 95 airplanes in the data sample. Lesser portions of the data are reported in references 3 through 11.

This report was prepared from the same data base used in reference 2. Information presented includes flight duration distributions for each of the 95 airplanes; comparisons of maximum and average indicated airspeeds of airplanes used in the same type of operations; distributions of indicated airspeeds in intervals of 10 or 20 knots for each of the 95 airplanes; comparisons of maximum and average operating altitudes of airplanes flown in the same type of operations; and distributions of flights flown in altitude intervals of 2000 or 5000 ft for each of the 95 airplanes. Comparisons are also made of the operating practices for a given airplane type flown in different types of operations.

SYMBOLS AND ABBREVIATIONS

$\bar{h}$ average altitude, ft

IAS indicated airspeed, knots

M_{MO} maximum operating-limit Mach number

NA not available

n_g gust limit load factor

n_m maneuver limit load factor

Pstn piston

SL sea level

$\bar{t}$ average flight duration, hr

T-jet turbojet

V_C design cruising speed, knots

V_D	design dive speed, knots
$\bar{V}_i$	average indicated airspeed, knots
V_{max}	maximum airspeed, knots
V_{MO}	maximum operating-limit airspeed, knots
V_{NE}	never-exceed speed, knots
V_S	stalling speed, knots
$1^1, 1^2, 1^3 \ldots$	superscripts indicate additional airplanes of same type

INSTRUMENTATION

Data were obtained from NASA VGH recorders described in reference 1. Briefly, these instruments record (on a time-history basis) the indicated airspeed of the airplane, pressure altitude based on standard atmospheric conditions, and normal acceleration measured at the airplane center of gravity. The recorder has three main components: a base containing the recording elements, a drum containing the recording paper, and a remote accelerometer. The recording base with the drum attached occupies a space about 8 in. high by 6 in. wide by 12 in. long. Their combined weight is 17 lb. The remote accelerometer is about 2 in. high by 2 in. wide by 7 in. long and weighs 2 1/4 lb. A photograph of the recorder is shown in figure 1, and a VGH record from an airplane flown in instructional operations is shown in figure 2.

Recorders used in the NASA VGH General Aviation Program were selected for a particular installation according to the airspeed capabilities of the airplane to be instrumented. These airplanes were instrumented with a 0- to 240-knot recorder, a 0- to 350-knot recorder, or a 0- to 460-knot recorder. All recorders used the same altitude range (-1000 ft up to infinity), and all except the aerobatic installation (6g to -3g) used the same acceleration range (4g to -2g).

DATA PRECISION

Although the accuracy of NACA/NASA VGH recorders has been defined over the years (refs. 1 through 12, for example), the following listings (charts A and B) indicate the maximum errors within specified flight regimes for the airspeed and altitude data. Extreme values of airspeed and altitude have been verified for each of the 95 airplanes.

Chart A.- Airspeed error

Flight regime	Airspeed interval (with corresponding maximum error), knots	Recorder
Takeoff and landing	40 (±5.0) to 80 (±2.0)	0 to 240 knots
Cruise	80 (±2.0) to 180 (±1.0)	↓
High speed	180 (±1.0) to 240 (±1.0)	
Takeoff and landing	60 (±7.0) to 120 (±3.0)	0 to 350 knots
Cruise	120 (±3.0) to 200 (±2.0)	↓
High speed	200 (±2.0) to 350 (±1.0)	
Takeoff and landing	100 (±7.0) to 150 (±4.0)	0 to 460 knots
Cruise	150 (±4.0) to 320 (±2.0)	↓
High speed	320 (±2.0) to 450 (±1.0)	

Chart B.- Altitude error

Pressure altitude, ft	Maximum error, ft
0	±160
5 000	±185
10 000	±205
15 000	±240
20 000	±275
25 000	±320
30 000	±385
35 000	±445
40 000	±585
45 000	±740

PROGRAM DESCRIPTION

The NASA VGH General Aviation Program was established in the early 1960's in response to a request by the Federal Aviation Administration for representative information on the gust and maneuver loads, and on the operating practices for modern general aviation airplanes. Five types of operations were initially selected as being typical of current usage: twin-engine executive, single-engine executive, personal, instructional, and commercial survey. Attempts were made to instrument at least three different types of airplanes in each of the operations, and to locate the airplanes such that their home bases were dispersed across the continental United States (fig. 3). Each potential participant was contacted by telephone, was given a brief description of the intent of the program, and, if interested, was visited and given an in-depth briefing of what would be involved in the program. Participation in the program was on a voluntary basis, although recorder installation and removal costs were borne by the government. In general, the majority of owners who were visited were sufficiently interested in general aviation and the VGH program to agree to participate in the program. As the program progressed, four additional operations were included: aerial application, aerobatic, commuter, and float operations.

Pertinent physical and design characteristics of the instrumented airplanes are given in table I. Physical characteristics were obtained from the manufacturer, from "Jane's All the World's Aircraft," or from the specifications sections of various Aerospace Forecast & Inventory issues of "Aviation Week & Space Technology." Design information was obtained from the airplane manufacturer or was calculated using references 13, 14, or 15. Each specific airplane type was assigned a number, with different models of that type assigned a letter designation after the number. When there were two or more airplanes of the same type or model, a numerical superscript was used to distinguish one from the other.

Although type of operation generally defines the mission that the instrumented airplanes were involved in, a more detailed definition of their mission is useful for data interpretation. The following tabulation of operations gives the airplanes involved in the operation, the airplane operator (individual, company, fixed-base operator, etc.), and the primary use of the airplane in the period that the data sample was taken.

Twin-engine executive:

Airplane type	Operated by	Primary use
$1,2,2A,3^1$	Companies	Business flights
$1^1,1^2,1^3,3$	Airplane manufacturers	Flight demonstration; executive transport; cargo carrier
4 and 5	Fixed-base operators	Charter flights; transition to heavier airplane; instrument flights; and check flights
5^1	Individual	Ambulance; business; and pleasure flights

Single-engine executive:

Airplane type	Operated by	Primary use
$6,7C,7C^1,9$	Individuals	Business and pleasure flights
7,7A,7B,8A	Companies	Business and cargo flights
$8,8A^1,9A$	Fixed-base operators	Charter flights for personnel and cargo; instrument check flights; and transition to heavier airplane

Personal:

Airplane type	Operated by	Primary use
10^{1},10A,12,12^{1}, 12^{2},12^{3},12A,13,13^{1}	Flying club	Pleasure, business, and instructional flights
10	Individual	Pleasure and business flights
11	Fixed-base operator	Pleasure, business, and instructional flights

Instructional:

Airplane type	Operated by	Primary use
12B,15,16,17, 18,18^{1}	Fixed-base operators	Basic flight instruction
$12B^{1}$,$12B^{2}$,14,14A	University	Basic flight instruction
4A	University	Twin-engine basic and advanced flight instruction; instrument instruction

Commercial survey:

Airplane type	Operated by	Primary use
4^{1},25,27	Contracted for by U.S. Forest Service	Lead planes for retardant tankers; check for excessive turbulence; mark drop site
9B	Contracted for by U.S. Forest Service	Scout for forest fires; transport cargo and personnel
23	U.S. Forest Service	Smoke jumper for fire fighters; personnel and cargo carrier
19,19^{1},20,20^{1},21, 22,24,24^{1},24^{2},24^{3} 24^{4},24^{5}	Contracted for by U.S. Forest Service	Drop retardant on forest fires
6A,17^{1},26	Gas and oil pipeline companies	Pipeline patrol over level and mountainous terrain
28	Individual	Fish spotting for commercial trawlers

Aerial application:

Airplane type	Operated by	Primary use
29, 29^{1}, 30, 30^{1}, 30^{2}, 30A, 31, 32, 32^{1}, 32^{2}, 33, 33^{1}, 33A, $33A^{1}$, $33A^{2}$, 34, 34^{1}, 34^{2}, 35, 35^{1}, 35^{2}, 36, 36A, 37, 37^{1}	Individuals and companies	Disperse chemicals for control of herbs, pests, and insects on farmlands
34^{3}	State	Disperse chemicals for control of herbs and insects on lakes and streams

Aerobatic:

Airplane type	Operated by	Primary use
38	Fixed-base operator	Aerobatic instruction and practice

Commuter:

Airplane type	Operated by	Primary use
39,40	Commuter airlines	Passenger flights; test and check flights

Float:

Airplane type	Operated by	Primary use
41	Fixed-base operator	Personnel and cargo charter; bush-type operations

RESULTS AND DISCUSSION

Airplane operating practices presented in this report relate to how airplanes in specific operations are being flown with respect to flight duration, airspeed usage, and altitude management. Table I lists pertinent physical and design characteristics for each type and model involved in the program, and table II provides the number of flights, the number of flight hours, the nautical flight miles, the average operating altitude, the average true airspeed, and the home base state for each airplane.

In the discussion that follows, results of the data analysis will be addressed in the following order: (1) flight duration, (2) airspeed practices, and (3) altitude management.

Flight Duration

The distribution of flights in multiples of 15-min duration is given in tables III(a) through III(i) for airplanes in nine types of operations. Figure 4 shows the average flight duration $\bar{t}$ and the percentage of flights that occur in each 15-min interval for each airplane. Flight times are defined here as the elapsed time from lift-off to touchdown. Exceptions to this definition are in personal, instructional, and float operations where air work coupled with touch-and-go landings (practice landings and takeoffs) were considered as one flight. Also, a flight in which only a series of touch-and-go landings were made was considered as a single flight.

Executive operations.- Examination of table III and figure 4 for trends that may be evident in a particular operation shows that airplanes in executive operations, both twin and single engine, have a general dispersion of flights up to about 5 1/2 hr, with roughly 80 percent of the flights having durations less than 2 hr. One exception to this is airplane 6; figure 4(b) indicates that 30 percent of its flights were less than 2 hr and 70 percent were more than 2 hr. All the airplanes except 1^3 recorded flights in the interval of 0 to 15 min, and the longest flight duration, 5 hr 30 min, was recorded by airplane 7 in single-engine executive operations. Average flight durations for airplanes in twin-engine executive operations extended from 45 min to 1 hr 39 min, with the majority in the interval of 45 min to 1 hr 15 min. For the single-engine executive operations, average flight durations were widely different for airplane types 6 and 7, ranging from less than 30 min to more than 2 1/2 hr, and were relatively consistent for airplane types 8 and 9, falling between 51 min and 1 hr 11 min.

Personal and instructional operations.- Flight durations for airplanes in personal and instructional operations (figs. 4(c) and 4(d)) show flights lasting up to 5 1/2 hr in personal operations and up to 4 1/4 hr in instructional operations. These flights were the exception, however, with 88 percent of personal operations flights lasting less than 1 1/2 hr, and 75 percent less than 1 hr. The percentage of shorter flight durations was even higher for instructional airplanes, where 97 percent of the flights lasted less than 1 1/2 hr, and 86 percent less than 1 hr. Average flight durations for airplanes in the two types of operations varied from 25 min to 1 hr 27 min for personal operations, and from 19 min to 53 min for instructional operations. The weighted average for the 11 personal airplanes was 47 min, and for the 11 instructional airplanes, 33 min. Although the average flight durations for both operations are seemingly short, it must be remembered that the ground time during taxi, touch-and-go landings, and landings to a full stop is not counted.

One instructional airplane showed a larger number of flights lasting from 0 to 15 min than the personal airplanes did, with the result that 86 percent of instructional airplane flights were <1 hr, whereas only 75 percent of personal airplane flights were <1 hr.

Commercial survey operations.- Figure 4(e) shows large differences in the distribution of flight durations for airplanes in commercial survey operations. Airplanes classed in commercial survey operations include those used as retardant tankers, lead planes to identify drop sites and check turbulence levels prior to retardant drops by the tankers, scout planes to detect and report forest fires, smoke jumper planes to carry fire fighters and fire fighting equipment into remote areas, pipeline patrol planes that check oil and gas pipelines for leaks, and commercial fish spotters. Commercial survey operations are therefore considered a conglomerate of operations, the flight characteristics of which would not be expected to relate one to the other.

The distribution of flight durations for airplanes used as retardant tankers is remarkably similar. (See fig. 4(e), airplane types 19, 20, 21, 22, and 24.) For this type of operation about 90 percent of the flights are less than 1 hr 15 min. Airplanes 20, 20[1], and 21 had a few flights that were as much as 7 hr 30 min in duration; however, these were ferry or cargo flights in which the airplanes were shifted from one location to another. Average flight durations for the retardant tankers ranged from a low of 19 min for airplane 24 to a high of 60 min for airplane 21. Airplanes used as lead planes (4[1], 25, and 27) also exhibited similar flight distributions. Ninety percent of the flights were under 3 hr, with no more than 16 percent of the flights occurring in any one 15-min interval. The average flight durations for the lead planes were relatively constant, varying from 1 hr 11 min to 1 hr 28 min.

The last two operations in forest fire fighting are smoke jumping operations and scouting operations. Differences between the two operations can be seen by comparing the distribution of flight durations for airplane 23 (smoke jumper) with that for airplane 9B (scout plane) in figure 4(e). Ninety-four percent of the flights of airplane 23 were 2 1/2 hr or less and the average duration was 1 hr 8 min. Airplane 9B, which performed search and scout operations, recorded 77 percent of its flights between 2 hr and 3 hr 15 min, and its average flight duration was 2 hr 21 min.

The final two operations covered in commercial survey operations are pipeline patrol and fish spotting. Three airplanes (6A, 17[1], and 26) were involved in pipeline patrol work, and one (28) in fish spotting. The flight distributions for the airplanes flying pipeline patrol were obtained from flights over both flat and mountainous country. The operations of airplane 6A were primarily over high mountainous terrain in Colorado, Utah, and Wyoming. Airplanes 17[1] and 26 were flown over Texas, Oklahoma, Louisiana, Arkansas, Kansas, Nebraska, Missouri, Iowa, and Illinois. Flight distributions for airplanes 6A and 26 did not exceed 4 hr 45 min and appeared to be generally confined to flights less than 4 hr. Airplane 6A has a relatively even distribution of flights up to 4 hr in duration, whereas the flights of airplane 26 peaked between 1 and 2 hr with over half (53 percent) occurring in this time interval. Airplane 17[1] recorded the longest flight duration (5 hr 35 min) of the three airplanes. Its flights were more heavily weighted in the time intervals 45 min to 2 hr, and 3 1/2 hr to 4 1/2 hr, which suggests that the airplane was used to patrol two separate pipeline routes. Average flight durations varied from a low of 1 hr 28 min for airplane 26, the largest airplane in the group, to 2 hr 33 min for airplane 17[1], the smallest of the three airplanes.

The percentage of flights of a given duration recorded by airplane 28 flown on commercial fish-spotting operations is shown in figure 4(e). Flights for this particular operation were conducted off the coasts of New Jersey, Maryland, Virginia, North Carolina, and South Carolina from May through November. The normal procedure for the airplane was to rendezvous with the fishing trawlers, search that area for schools of menhaden, direct the trawlers to the schools, direct the net boats to encircle the schools, and finally notify the trawlers when to retrieve the nets and fish. Figure 4(e) indicates that airplane 28 recorded the longest flight duration, 8 hr 45 min, of any airplane in the nine types of operations investigated. The distribution of flights for airplane 28 shows that there was no concentration of flights in any one time interval, rather a regular dispersion of flights with the largest number, less than 6 percent, occurring between 4 hr 15 min and 4 hr 30 min.

Aerial application operations.- Aerial application, by definition, is the dispersion of herbicide, insecticide, pesticide, fertilizer, or seed on specified areas by means of an airplane or helicopter. In normal operating procedures the aircraft are loaded with chemicals or seed at a home or remote field and flown to the area to be treated; then they disperse the chemicals or seeds at preselected airspeeds and altitudes above ground level and return to their operating base to be reserviced. Figure 4(f) gives the percentage of flights flown in intervals of 15 min by 26 agricultural airplanes. The data shown are for the complete data sample for each airplane, and therefore include flights other than aerial application; however, the data are considered typical of agricultural airplane usage. All the airplanes except 34, 34^2, and 34^3 expended at least 86 percent of their flights on agricultural missions. Airplanes 34, 34^2, and 34^3 used 71, 65, and 80 percent, respectively, of their flights for agricultural work, and used the remainder for cross-country or familiarization flights. Flight durations for agricultural flights vary widely, from those occurring within the interval of 0 to 15 min to those in the interval of 2 hr 45 min to 3 hr. The large differences in flight duration arise for a number of reasons, the more significant being field size, rate of application, and ferry time. The differences illustrate the varied requirements imposed on agricultural airplanes.

The similarity of flight duration distributions for different airplanes used in a single operation is seen by comparing the flight distributions of airplanes 30 and 30^2, flown by an operator in the Pacific Northwest, and those for airplanes 32, 32^2, $33A^1$, and $33A^2$, flown by an operator in the south-central region of the United States. For all practical purposes the flight duration distribution for airplane 30 is almost a carbon copy of that for airplane 30^2. The same applies to airplanes 32 and 32^2, and airplanes $33A^1$ and $33A^2$, which implies the distributions of agricultural flight durations are dependent to a large extent on the operator. Established operators usually have regular customers whose fields are treated year after year, and this is reflected in the consistent flight duration distribution for a given operator.

Other operations.- The percentage of flights in intervals of 15 min for the last three operations (aerobatic, commuter, and float) are given in figures 4(g), 4(h), and 4(i), respectively. Airplane 38, designed for aerobatic flight, was used by a fixed-base operator on the east coast of the United States for basic aerobatic instruction. Only aerobatics that resulted primarily in positive loads on the airplane structure were performed. Inverted aerobatics (outside loops, snaps, Immelmanns, rolls, or spins) that induce large negative accelerations were not made. Flights up to 2 hr were recorded; however, 90 percent of the flights were 1 hr or less, and the average flight duration was 31 min. The flight duration distribution for the aerobatic operation was similar to that for instructional operations.

Airplanes 39 and 40 in figure 4(h) were flown in commuter operations on the west and east coasts of the United States, respectively. Airplane 39 was flown in California (intrastate) and airplane 40 in New York, New Jersey, Pennsylvania, Maryland, and Virginia (interstate). Both airplanes recorded flights up to 2 hr; however, 95 percent of the flights of airplane 39 were 30 min or less, whereas only 55 percent of the flights of airplane 40 were less than 30 min. The average flight duration for airplane 39 was 17 min, about half the 31-min average for airplane 40. These data indicate that commuter operations may occasionally include flights up to 2 hr, but the vast majority (95 percent) of the flights are less than 1 hr.

Airplane 41, flown by a fixed-base operator in one of the Pacific-Northwest States, was used as a float plane in bush-type operations. Cargo and passengers were carried both near and far from the home base to normally inaccessible areas. Some landings were made on glaciers in high mountainous regions. The longest flight was 3 hr 6 min, and the average flight was 33 min. About 44 percent of the flights were 15 min or less, and 99 percent were under 2 hr.

Five types of airplanes in the 95-airplane data sample were involved in more than one type of operation: type 4 in twin-engine executive, instructional, and commercial survey operations; type 6 in single-engine executive and commercial survey operations; type 9 in single-engine executive and commercial survey operations; type 12 in personal and instructional operations; and type 17 in instructional and commercial survey operations. A comparison of the flight durations of airplane type 4 used in different operations (figs. 4(a), 4(d), and 4(e)) shows the maximum flight durations in all three operations were the same, 4 hr to 4 hr 15 min, but the distribution of flights of shorter duration differed. Instructional operations recorded shorter flights, with 88 percent less than 1 hr. Flights by airplane type 4 in executive and commercial survey operations were more dispersed, with about 90 percent under 1 hr 30 min, and 2 hr 45 min, respectively.

Airplane type 6, flown in single-engine executive and commercial survey operations, recorded flight durations up to 5 hr 15 min in executive operations (fig. 4(b)) and up to 4 hr 45 min in commercial survey operations (pipeline patrol) (fig. 4(e)). Average flight durations were also higher in executive operations, 2 hr 31 min compared with 1 hr 58 min; however, airplane 6 with its pressurized cabin was designed to operate at higher altitudes, and because of this would be expected to be used for longer than normal single-engine executive flights. This particular comparison may be biased, not only in regard to flight duration but also in regard to airspeed and altitude operating practices. It therefore will not be considered in later comparisons of a given type airplane used in different types of operations.

A comparison of the flight distributions of airplane type 9 (figs. 4(b) and 4(e)) indicates a general similarity for types 9 and 9A in executive operations; that is, the percentage of flights of a given duration was higher for the shorter flight durations, then gradually decreased to a lower percentage as the flight duration increased. Airplane 9B, flown as a search and scout plane for forest fires in commercial survey operations, recorded most of its flights between 2 hr and 3 hr 15 min, with the average duration being more than twice that for airplanes 9 and 9A in executive operations. Airplane type 12, flown in personal and instructional operations (figs. 4(c) and 4(d)), recorded longer flight durations in personal operations (4 1/2 hr compared with 3 1/4 hr); however, average flight durations in both operations were about the same. The most apparent difference between the two types of operations by the same airplane type was the higher percentage of flights in the intervals of 0 to 15 min and 15 to 30 min in personal operations. Airplane type 17, flown in instructional operations and on pipeline patrol in commercial survey operations, illustrates in figures 4(d) and 4(e) the influence that the type of operation can have on the distribution of airplane flight durations. Figure 4(d), instructional operations, shows that airplane 17 recorded 92 percent of its flights under 1 hr 30 min; its maximum flight duration was 3 hr 26 min; and its average flight duration was 46 min. In contrast to this, 92 percent of the flights of airplane 17[1] in commercial survey operations (fig. 4(e)) included flights up to 4 hr 30 min. The maximum flight duration was 5 hr 35 min, and the average flight was 2 hr 33 min - more than three times that for the same type airplane flown in instructional operations.

Maximum and Average Airspeeds

Although knowledge of the variation in flight durations to be expected from a given type of operation is desirable, other types of information related to operating practices, such as airspeed practices and altitude management, are also important to the designer or analyst. This section of the report will deal with airspeed practices for the 95 instrumented airplanes in the data sample. Table IV lists the time flown in specified airspeed intervals for each airplane in the nine types of operations, and figure 5 gives the maximum and average airspeeds for each of the airplanes. Table IV is presented to provide the reader with the basic data for each airplane. These data may be used to combine samples from like airplanes, or from different airplanes in a similar type of operation. The discussion will deal primarily with figure 5.

Executive operations.- Figure 5(a) shows that the highest indicated airspeed, 398 knots, was recorded by a turbojet-powered, twin-engine executive transport airplane, 1^2. Average indicated airspeeds differed widely between the turbojet-powered and the turboprop- and piston-powered airplanes in twin-engine executive operations, averaging about 242 knots for the turbojet-powered planes and about 153 knots for the turboprop- and piston-powered planes. The distribution of maximum and average airspeeds for airplanes in single-engine executive operations (fig. 5(b)) appears to be the most uniform of all the operations, showing variations of maximum indicated airspeed of up to 43 knots and variations of average indicated airspeeds of up to 28 knots. The relatively uniform distribution of these airspeeds suggests that the performance of the airplanes used in the operation was generally alike, and that the missions performed by the individual airplanes were similar.

Personal and instructional operations.- Comparisons of airspeeds for airplanes in personal and instructional operations, figures 5(c) and 5(d), respectively, show similar variations in maximum airspeeds for the two operations, 111 to 165 knots for personal and 101 to 165 knots for instructional airplanes - provided twin-engine instructional airplane 4A is not considered. Differences in average airspeeds are more pronounced between the two operations, ranging from 83 to 128 knots for personal airplanes and from 70 to 87 knots for instructional airplanes, again not considering airplane 4A. The lower average airspeeds for airplanes in instructional operations are believed to result both from the large percentage of flights devoted to practicing touch-and-go landings and from the demonstration of slow flight and stall recovery procedures. Although these types of flights are seen on VGH records from airplanes flown in personal operations, they occur less often.

Commercial survey operations.- Maximum and average airspeeds for airplanes flown in commercial survey operations are shown in figure 5(e). Airplane types 19, 20, 21, 22, and 24 were used as fire retardant tankers; airplanes 4^1, 25, and 27, as lead planes; airplane 9B, as a search and scout plane; and airplane 23, as a smoke jumper in forest fire fighting operations. Airplanes 6A, 26, and 17^1 were used on pipeline patrol flights to check for oil or gas leaks, and airplane 28 was used as a fish spotter for a commercial fishing fleet. Maximum airspeeds for fire retardant tankers varied from a high of 315 knots for airplane 21 to a low of 180 knots for airplane 24^5. Average airspeeds ranged from 134 to 167 knots. Like airplane types tended to have reasonably similar average airspeeds; however, differences in maximum airspeeds were sometimes large. Of the three airplane types for which comparisons between operators were available (19, 20, and 24), airplane type 24, flown by three operators, recorded the largest difference between average airspeeds, 13 knots, and between maximum airspeeds, 62 knots. Airplanes 24^2, 24^3, and 24^5, flown by one operator, recorded appreciably lower maximum airspeeds than airplane 24 or airplanes 24^1 and 24^4, flown by the other two operators. From these data it appears that airspeed practices are influenced by operator-pilot training and discipline. It is strongly suspected that this is so; however, since the airplanes were flown over different terrain (they were based in the same state, but at different locations), the locations of the fires (mountainous or flat terrain) may have dictated higher or lower airspeeds.

Airplanes 4^1, 25, and 27 were flown as lead planes in forest fire fighting. As such they preceded the run of the retardant tanker, marked the drop area, and checked the descent path for excessive turbulence. Airplanes 4^1 and 25 were powered by two engines (now a requirement for fire fighting operations), and airplane 27 was powered by one engine. The average airspeeds for 4^1 and 25 were 139 and 138 knots, respectively, and that for airplane 27 was 114 knots (fig. 5(e)). The 24- to 25-knot difference reflects the speed differences between the twin- and single-engine-powered airplanes. Maximum airspeeds recorded by the three airplanes were between 183 and 197 knots with the single-engine plane recording 191 knots. The higher maximum airspeed relative to average airspeed for airplane 27 compared with airplanes 4^1 and 25 implies, for airplane 27, either task-related requirements for an occasional high-speed run, or as with the retardant tankers, lack of pilot discipline.

The last airplanes in the fire fighting operation (23 and 9B), flown on smoke jumping and scouting missions, recorded average airspeeds of 124 and 100 knots and maximum airspeeds of 173 and 145 knots, respectively. Neither airplane, probably because of mission-related requirements, recorded excessive maximum airspeeds.

Of the last four airplanes flown in commercial survey operations, three were involved in pipeline patrol work and one in commercial fish spotting. The three in pipeline patrol, 6A, 17^1, and 26, recorded average airspeeds from a low of 87 knots to a high of 139 knots. Maximum airspeeds ranged from 123 knots to about 180 knots. In general, airplanes flown on pipeline patrol recorded higher average indicated airspeeds than the same type of airplanes flown in other operations. These higher airspeeds resulted from flying at advanced throttle settings to cover the prescribed patrol routes in minimum time, thus providing efficiency and economy to the operation. Airplane 28, flown as a commercial fish spotter, recorded an average airspeed of 58 knots and a maximum airspeed of 103 knots. The low average airspeed is typical for fish spotting because of the "loiter" airspeeds necessary for flight duration and observation.

Aerial application operations.- The average and maximum airspeeds recorded by airplanes used in aerial applications are given in figure 5(f). Agricultural airplane types 29 and 32 were considered to be in the heavy turbine class; types 30, 31, and 33 in the heavy piston class; and types 34, 35, 36, and 37 in the light piston class. Average airspeeds for all classes varied from 70 to 116 knots, and maximum speeds from 94 to 142 knots. The highest average airspeed was recorded by one of the heavy turbine-powered airplanes, 29, as expected. It was not expected that two of the light piston-powered airplanes, 35^1 and 35^2, would have average airspeeds equal to or higher than those for two of the heavy turbine-powered airplanes, 32 and 32^2, or that one of the heavy turbine-powered airplanes, 33A, would record next to the lowest average airspeed of all the airplanes in aerial application operations. The variation in average airspeed for the same airplane types indicates the effect that differences in ferry time (flight to and from fields to be worked), field size, and obstacles around the perimeter of the field have on airspeed. Smaller differences in average airspeed normally exist between airplanes of the same type flown over the same group of fields by pilots in the same company, for example, airplanes 32 and 32^2. Maximum airspeeds, particularly in aerial application operations, appear to be affected by pilot training and discipline, as evidenced by the relatively large differences in maximum airspeeds for the same airplane types.

Other operations.- Average and maximum airspeeds for airplanes in the last three operations - aerobatic, commuter, and float - are shown in figures 5(g), 5(h), and 5(i), respectively. Airplanes 39 and 40 in commuter operations recorded the highest average and maximum speeds of the four airplanes considered. Both were turbine powered and typical of those used in commuter service. The differences between average airspeeds, and between maximum airspeeds for airplanes 39 and 40 illustrate the range of acceptable airspeeds for commuter airplanes. Airplane 38, flown in aerobatic operations, showed a less-than-expected difference between its average and maximum airspeeds considering the maneuvers flown (loops, split-S's, and lazy eights) that tend to generate high speeds, particularly by student pilots. Airplane 41, flown as a bush plane in float operations, had an average airspeed of 98 knots and a maximum airspeed of 140 knots.

Airspeed Distributions

Figure 6 gives the percentage of time flown in airspeed intervals of 10 or 20 knots, the average altitude $\bar{h}$ recorded within these intervals, the computed stalling speed V_S, the design cruising speed V_C, the average indicated airspeed $\overline{V}_i$, and the never-exceed speed V_{NE} for each of the 95 airplanes in the data sample. When V_C or V_{NE} was not known for a particular airplane, or if V_C or V_{NE} occurred beyond the scale for the figure, they were not shown. The design and never-exceed speeds shown in the figures are for sea level conditions. Average altitude values recorded in the given airspeed intervals are shown above or within each bar on the histogram and are provided primarily for general information to the reader. In the following discussion airspeed range refers to the airplane airspeed from 0 through V_{max}. It is used to compare the airspeed practices of both individual airplanes and groups of airplanes flown in different types of operations.

Executive operations.- Examination of figure 6(a), depicting twin-engine executive operations, shows that the airplanes were flown in the upper half of their airspeed range 80 to 90 percent of their flight time. Airspeeds less than V_S occurred when lightweight, flapped, power-on landings were made. The design cruising speed was equaled or exceeded less than 10 percent of the time, and only airplane 3^1 of the turboprop- or piston-powered airplanes reached or exceeded V_{NE}. Whether turbojet-powered airplane types 1 or 2 reached or exceeded V_{MO} or M_{MO} cannot be determined from the data as presented, since the maximum operating airspeed varies with altitude, and the altitude at which the airspeed was recorded is not shown.

The airspeed distribution for airplanes flown in single-engine executive operations is shown in figure 6(b). These distributions indicate that the single-engine executive airplanes were flown in the upper 50 percent of their airspeed range 95 percent of the time - 5 to 15 percent more than the twin-engine executive airplanes. There was little difference in the percentage of time flown in the vicinity of V_S for the twin- or single-engine executive airplanes powered with piston or turboprop engines; however, the turbojet-powered twins were flown a larger percentage of time near V_S. All the single-engine executive airplanes reached or exceeded V_C, and airplanes 6 and 9A recorded airspeeds equal to or in excess of V_{NE}.

Personal and instructional operations.- An examination of figures 6(c) and 6(d) shows that airplanes in personal operations are flown in the lower half of their airspeed range about 4 percent of their flight time. This compares with about 16 percent of the flight time for airplanes in instructional operations. The larger percentage in the lower speed range for instructional airplanes is a result of the relatively large portion of time devoted to training the student pilot in how to fly in traffic patterns; how to land, control the airplane, and takeoff; and what to expect in flight at slow and near-stall speeds. It is also noted that instructional airplanes are flown at or below V_S a larger percentage of time than airplanes in personal operations, 2.4 percent versus 0.1 percent. This result occurs because of the time spent by instructors demonstrating stalls and spins. The airspeeds below V_S are believed to occur after the onset of stall in stall or spin entries. The design cruising speed was equaled or exceeded by all but three airplanes, 12, 12A, and 13^1, in personal operations, and by all airplanes in instructional operations. Personal airplanes were flown above V_C a maximum of 20 percent of the flight time (airplane 10A), but usually 3 percent of the flight time or less. Instructional airplanes were flown above V_C a maximum of about 22 percent of the time (airplanes 18 and 18^1), with most of the airplanes exceeding V_C 1 percent of the time or less. The never-exceed speed was equaled or exceeded by only one airplane (10A) in personal operations and by three airplanes (14, 17, and 18^1) in instructional operations. In general, the data show that airplanes in both personal and instructional operations were flown in a relatively conservative manner, with only four airplanes in the combined operations exceeding the placard speed V_{NE}. There were no airplanes in either operation that reached or exceeded the design dive speed V_D.

Commercial survey operations.- The percentage of time flown in various airspeed intervals by airplanes in commercial survey operations is given in figure 6(e). Airplane types flown as retardant tankers (19, 20, 21, 22, and 24) spent roughly 95 percent of their flight time at airspeeds in the upper 50 percent of their airspeed range. Airplane 21 was flown in this airspeed range only 48 percent of its flight time because of an isolated high-speed occurrence. Lead planes 4^1 and 25, scout plane 9B, and jump plane 23 in forest fire fighting service all recorded about 95 percent of their flight time in the upper 50 percent of their airspeed range, as did airplanes 6A, 26, and 17^1 flown on pipeline patrol and airplane 28 flown as a fish spotter for commercial fishing fleets. Airplane 27, a lead airplane in forest fire fighting operations, was flown in the upper 50 percent of its airspeed range 76 percent of the time, a lesser percentage of its flight time than the majority of the airplanes, again because of an isolated high-speed occurrence. All airplanes except types 19, 20, and 22 equaled or exceeded their design cruising speed. Only airplane 21 equaled or exceeded its never-exceed speed, and none of the airplanes reached the design dive speed.

Aerial application operations.- Figure 6(f) gives the percentage of time flown in airspeed intervals of 10 knots by airplanes used in aerial application operations. Eighteen of the 26 airplanes were flown in the upper 50 percent of their airspeed range 99 percent of the time, and 8 of the airplanes at least 96 percent of the time - an average of 98.4 percent of the time for the 26 airplanes in this operation, and the highest for the 9 types of operations. Examination of operational speeds shows 15 airplanes were flown at speeds that never reached V_C; 11 airplanes were flown at speeds that equaled or exceeded V_C; and 3 of the airplanes recorded speeds in excess of V_{NE}. Differences in airspeed practices by different operators flying the same type of airplane can be seen by comparing the bar graphs in figure 6(f) for the following airplanes: 29 with 29^1; 30 with 30^1; 32 with 32^1; 33 with 33^1; 33A with $33A^1$; 34 with 34^1, 34^2, and 34^3; 35 with 35^1 and 35^2; and 37 with 37^1. These comparisons illustrate the sometimes similar, sometimes random differences in airspeed usage by the operators. The variations are believed to be caused by differences in ferry distances to and from work areas, field sizes (affects number of spreading runs and turns per flight), rate of dispersal (high, medium, or low volume), and pilot technique. Comparisons of airspeed distributions for the same airplane types (30 and 30^2, 32 and 32^2) flown by different pilots working for the same operator show similar results.

Other operations.- The percentage of time flown in airspeed intervals of 10 knots by airplanes in aerobatic, commuter, and float operations is given in figures 6(g), 6(h), and 6(i), respectively. All the airplanes were flown at speeds equal to or above V_C, but only airplane 38 in aerobatic operations and airplane 41 in float operations exceeded V_{NE}. Airplane 38 was flown in the lower 50 percent of its airspeed range about 45 percent of the time. This is believed to result from operations at low speeds for reasons described in the discussion on airplanes involved in instructional operations and, in addition, from flight at reduced airspeeds to avoid overspeeds and/or structural damage during entry and performance of certain aerobatics. Airplanes in commuter and float operations were flown in the lower 50 percent of their speed range only about 4 percent of the time, with the majority of their flight time spent at cruising speeds in the upper half of their airspeed range.

A comparison of airspeed distributions for the same airplane types used in different operations shows that airplanes flown in instructional operations have more even distributions than those flown in twin-engine executive, personal, or commercial survey operations (airplane types 4, 12, and 17). Airplanes 4 and 9, flown in executive operations, exhibited a larger percentage of airspeeds in a relatively narrow band, usually defined by the cruising speeds.

Maximum and Average Altitudes

Information pertaining to the altitude management of general aviation airplanes is presented in the last section of the report. Table V gives the hours of flight in altitude intervals of 5000 ft for turbojet-powered airplanes, and in altitude intervals of 2000 ft for turboprop- or piston-powered airplanes. Figure 7 lists the maximum and average operating altitudes for each of the airplanes and is presented to show altitude envelopes for different operations and to allow a comparison of the altitude experience of individual airplanes. Table V is given to provide the reader with a means of combining airplane types or operations for comparative purposes. In the discussion that follows, only data related to figure 7 will be discussed.

Executive operations.- Figures 7(a) and 7(b) show graphically the differences in operating altitudes between turbojet-, turboprop-, turbocharged-piston, and piston-powered executive airplanes. The turbojet-powered airplanes, types 1 and 2, recorded maximum altitudes between 40 000 and 45 000 ft, with average operating altitudes between 20 000 and 30 000 ft. Turboprop-powered airplanes, type 3, were flown to maximum altitudes between 21 000 and 24 000 ft and had average cruising altitudes between 10 000 and 12 000 ft. The turbocharged, piston-powered, pressurized cabin, single-engine executive airplane (type 6) had a maximum altitude that was in the range defined by the turboprop-powered, twin-engine executive airplanes and had an average operating altitude that was about 2000 ft higher than that for either of the twin-engine, turboprop-powered executive airplanes. Maximum altitudes for the piston-powered, nonturbocharged executive airplanes, both twin and single engine, extended from 8000 to 16 000 ft with the majority between 11 000 and 15 000 ft. Average operating altitudes varied from 4000 to 8000 ft; for seven of these airplanes the average altitude was below 5000 ft, whereas for the remaining six airplanes the average altitude was between 7000 and 8000 ft.

Personal and instructional operations.- Figures 7(c) and 7(d) give maximum and average operating altitudes for airplanes flown in personal and instructional operations. Maximum altitudes for airplanes in personal operations were less uniform than for those in instructional operations. Airplanes flown in personal operations reached maximum altitudes of from 7000 to 19 000 ft, whereas those flown in instructional operations had maximum altitudes of about 8000 to 15 000 ft. If airplane 10A is not considered, maximum altitudes for personal airplanes would fall within the same limits. The altitude of 19 000 ft recorded by airplane 10A was reached by one of the flying club members attempting to determine how high that particular airplane would fly. That altitude provides a valid data point, but it is not considered typical. The spread in average operating altitudes for airplanes flown in personal operations, from 1000 to 7000 ft, is the same for airplanes flown in instructional operations; however, for the instructional airplanes all but one, 17, had average operating altitudes between 1000 and 3000 ft. If the home field elevation of 5000 ft for airplane 17 is considered, its average operating altitude above ground level would also fall between 1000 and 3000 ft. It appears that airplanes involved in instructional operations are flown in more constrained altitude intervals than airplanes in personal operations, and that flight instruction is relatively consistent in different sections of the country and by different flight schools. The differences in maximum and average altitude distributions for airplanes flown in personal operations illustrate the varied types of flights by the different flying clubs.

Commercial survey operations.- Airplanes used in forest fire fighting operations (fig. 7(e)) recorded maximum altitudes from 4900 to 14 880 ft and average operating altitudes from 1950 to 8160 ft. Both maximum and average altitudes were affected by the geographical area in which the airplanes were operated; those in mountainous regions recorded higher maximum and average altitudes. Maximum altitudes for airplanes flown on pipeline patrol ranged from 3200 to 17 600 ft, with average operating altitudes extending from 1150 to 6080 ft. The altitude practices of these operations were also influenced by operations over mountainous regions (airplane 6A), or over flatlands (airplane 17[1]). Airplane 28, flown primarily over water in commercial fish-spotting operations, recorded a maximum altitude of 6250 ft and had an average operating altitude of 1700 ft. The higher altitudes for airplane 28 were recorded on cross-country flights and on extended flights to reach the fishing fleets.

Aerial application operations.- Airplanes used in aerial application operations (fig. 7(f)) recorded maximum altitudes from 640 ft to 15 300 ft and had average operating altitudes from less than 100 ft to 4980 ft. Maximum altitudes for this type of operation usually occurred on ferry flights, pleasure flights, or test flights - not on operational flights. Geographical location particularly influenced average altitudes since operational flights were flown near ground level. The large percentage of flight time near ground level by agricultural airplanes is indicated when a comparison of home airfield elevation with average operating altitude shows the two values to be about the same.

Other operations.- Figures 7(g), 7(h), and 7(i) show maximum and average altitudes for airplanes in aerobatic, commuter, and float operations, respectively. The maximum altitude reached by airplane 38 (fig. 7(g)) was 6500 ft, and the average operating altitude was 1660 ft. Fifty-nine percent of the flight time of airplane 38 was used for aerobatic instruction and practice, and the remaining time for basic flight instruction. Airplanes 39 and 40 (fig. 7(h)) flown in commuter operations recorded maximum altitudes of 11 040 and 14 300 ft, and average operating altitudes of 2320 and 4280 ft, respectively. The relatively low average and maximum altitudes for the turboprop-powered commuter airplanes, compared with turboprop-powered airplane type 3 flown in twin-engine executive operations (fig. 7(a)), were a result of short flights, which are characteristic of commuter operations. Because of the short flights - average duration 18 to 32 min (fig. 4(h)) - it was not time efficient to operate at the higher altitudes used by the twin-engine executive turboprop airplanes. Airplane 41, a float-equipped airplane used in bush-type operations, was flown to a maximum altitude of 14 370 ft and had an average operating altitude of 2505 ft.

Altitude Distribution

Although figures 7(a) through 7(i) give envelope-type altitude information for airplanes in the nine types of operations, it is also of interest to know the amount of time that individual airplanes, or combined airplanes in a specific operation, spend in given altitude intervals. Figures 8(a) through 8(i) provide such data giving the percentage of time that turbojet- and turboprop-powered airplanes are flown in altitude intervals of 5000 ft, and the percentage of time that piston-powered airplanes are flown in altitude intervals of 2000 ft. Also noted in the figures is the average operating altitude for each airplane. Average indicated airspeeds in the altitude interval are noted above or within each bar on the histogram.

Executive operations.- An examination of the percentage of time flown in various altitude intervals by the turbojet-powered executive airplanes (types 1 and 2) shows that the airplanes averaged about 49 percent of their flight time above 30 000 ft (fig. 8(a)). Below 30 000 ft, however, there were differences in the amount of time flown in specific altitude bands. Airplanes 1^1 and 1^2 were used as demonstrators to promote the sale of a specific airplane type, and as such they tended to spend more time in the lower altitudes. Airplane 2A, although used as an executive transport, was the first turbojet airplane owned by the company. Because of the transition from piston-powered to turbojet-powered airplanes, more time than usual (32 percent) was spent below 10 000 ft on familiarization flights. Airplanes 1, 1^3, and 2 are believed to be representative of typical turbojet-powered executive transport operations, consuming about 17 percent of their flight time below 10 000 ft, about 26 percent between 10 000 and 30 000 ft, and about 57 percent above 30 000 ft.

Turboprop-powered airplanes 3 and 3^1 (fig. 8(a)) and turbocharged, pressurized, piston-powered airplane 6 (fig. 8(b)) were also flown as executive transports. Airplane 3, although used as an executive transport, was primarily flown as a flight demonstrator, and as such was operated in the lower altitudes, 0 to 4000 ft, a larger percentage of time (20 percent) than airplane 3^1 (15 percent) or airplane 6 (11 percent).

Piston-powered airplanes flown as executive transports, types 4, 5, and 7 through 9, were operated, as expected, at significantly lower altitudes than were turbojet-, turboprop-, or turbocharged-piston-powered executive transports. If weighted averages are taken for the executive transports, the results show that the turbojets are flown between 30 000 and 45 000 ft 50 percent of the time; turboprop and turbocharged-piston transports are flown between 10 000 and 24 000 ft 56 percent of the time; and the piston transports are flown above 10 000 ft 7 percent of the time, with the majority of their flight time, 82 percent, between 2000 and 10 000 ft.

Personal and instructional operations.- The percentage of time flown in altitude intervals of 2000 ft by airplanes in personal and instructional operations is shown in figures 8(c) and 8(d). Airplanes in both types of operations recorded an insignificant percentage of their flight time above 10 000 ft, recording a weighted average of 2 percent for those in personal operations and a weighted average of 0.2 percent for instructional airplanes. A relatively large amount of time, 35- and 44-percent weighted average, respectively, for the two operations was recorded below 2000 ft. Operations in this altitude interval reflect the time spent by pilots in personal or instructional operations practicing full-stop landings, touch-and-go landings, and airfield traffic pattern entrances and departures. Altitude intervals between 2000 and 10 000 ft were the primary work intervals for airplanes in both operations - used by personal airplanes 62 percent of the time for cross-country, pleasure, and practice flying, and by instructional airplanes 56 percent of the time for instructional air work and solo practice by the students.

Commercial survey operations.- The percentage of time flown in altitude intervals of 2000 ft by airplanes involved in commercial survey operations is given in figure 8(e). Airplanes used as air tankers to drop retardant chemicals on forest fires (types 19, 20, 21, 22, and 24) were flown below 10 000 ft 97 percent of their flight time based on a weighted average of all the air tanker data samples. Differences were noted, however, between the altitude intervals frequented by air tankers operated in Oregon (types 19 and 21) and Arizona (type 20) and those operated in California (types 22 and 24). Air tankers based in Oregon and Arizona were flown below 2000 ft 9 percent of their time compared with 33 percent for the California air tankers; between 2000 and 10 000 ft 87 percent of the time compared with 67 percent; and above 10 000 ft 4 percent of their flight time compared with 0.2 percent. Differences between the airplane altitude practices of the two sets of data are believed to be a direct result of the topography over which the fire fighting flights were made. The Oregon and Arizona tankers were flown over high, rugged mountains, and the California tankers over lower elevations with less mountainous terrain.

Lead airplanes were flown below 2000 ft from 2 to 13 percent of their flight time. Airplanes 4[1] and 25 were apparently operated in generally similar altitude intervals, recording about 84 to 90 percent of their flight time between 2000 and 10 000 ft, and 9 to 10 percent of their time above 10 000 ft. Airplane 27, on the other hand, recorded 77 percent of its time between 2000 and 8000 ft, and only 10 percent above 8000 ft. The smoke jumper airplane (23) was seldom flown in the altitude interval of 0 to 2000 ft, probably because its home airfield elevation was above 2000 ft, and because the airplane was used primarily in high mountain regions. It flew about half of its time between 2000 and 8000 ft, and half between 8000 and 16 000 ft. Scout airplane 9B was flown less than 7 percent of its time in each altitude interval of 2000 ft up to 12 000 ft, except between 6000 and 8000 ft, where it spent 81 percent of its flight time. Mountain peak elevations within 150 miles of the home airfield of airplane 9B extended from 3500 to 9500 ft with the majority between 3500 and 5500 ft. From this it appears that the scout airplane was flown from 2000 to 4000 ft above ground level in its scouting and observation mission.

Airplanes 26, 6A, and 17[1], flown on pipeline patrol, represent typical patrol operations over flat, mountainous, and high mountainous terrain. Airplane 17[1] was flown between Houston, Texas, and Chicago, Illinois. It was never flown above 4000 ft, and 94 percent of its flight time was below 2000 ft. Airplane 26 was flown over pipelines transversing both high and low elevations with 50 percent of its time flown below 2000 ft and 46 percent between 2000 and 8000 ft. Airplane 6A was flown in the Rocky Mountain regions of Colorado, Wyoming, and Utah and consequently encountered the most hostile environment of the three pipeline patrol airplanes. Its home airfield elevation was 5355 ft; it was flown below 4000 ft 13 percent of the time, between 4000 and 10 000 ft 81 percent of the time, and between 10 000 and 18 000 ft 6 percent of the time.

Airplane 28, the last airplane in commercial survey operations, was flown as a fish spotter for commercial fishing trawlers. It was never flown above 8000 ft, and it was operated between 2000 and 6000 ft 30.4 percent of the time and below 2000 ft 69.5 percent of the time. Conversations with the pilot indicated that fish-spotting altitudes were usually around 1700 ft with occasional excursions above and below this altitude.

Aerial application operations.- Figure 8(f) gives the percentage of time flown in altitude intervals of 2000 ft by airplanes used in aerial application operations. All the airplanes except those whose home bases were above 2000 ft and those ferried to remote locations from the home base were flown in the interval from 0 to 2000 ft about 100 percent of the time. There appeared to be little difference between the altitude operating practices of the heavy turbine-powered, the heavy piston-powered, or the light piston-powered airplanes. All were flown close to ground level during dispersal of the chemicals and in flights to and from the work areas.

Other operations.- The percentage of time flown in altitude intervals of 2000 ft by airplanes used in aerobatic, commuter, and float operations is shown in figures 8(g), 8(h), and 8(i), respectively.

Airplane 38, flown in aerobatic operations (fig. 8(g)), recorded 61 percent of its flight time below 2000 ft - an unexpected result. It was thought that the largest percentage of the flight time would be between 2000 and 6000 ft, since an altitude cushion is necessary for aerobatic practice. In an attempt to explain why such a large percentage of time was flown below 2000 ft, VGH records from airplane 38 were examined with particular attention given to the type of flight made and to the altitude trace history of the flight. The results of the record scan indicated 56 percent of the flights were aerobatic, 22 percent were cross-country flights, and 22 percent were touch-and-go landing practice flights. The cross-country flights accounted for 21 percent of the data sample time. They were relatively short in duration, 28.5 min on average, and were generally conducted below 2000 ft. The touch-and-go landing flights represented 20 percent of the flight time, averaged 27.7 min per flight, and were all below 2000 ft. Aerobatic flights accounted for 59 percent of the flight time. They averaged 32.2 min and during aerobatic instruction or practice were flown between 2500 ft and about 6000 ft. The aerobatic practice area was 15 n.mi. from the home airfield and required 6 min to reach. Conversations with the instructor pilot indicated that although departure from the home airfield usually consisted of a steady climb to about 6000 ft, the return to base was usually made at low altitudes (below 2000 ft) since the aerobatics were finished in the low altitude portion of the aerobatic altitude spectrum, and the low return to base was made to avoid relatively heavy civil and military traffic in the area. Although these particular aerobatic flights seem to have been flown in an unusually low altitude environment, the proportion of cross-country and touch-and-go flights to aerobatic flights, the airspeed practices, and the acceleration experience (ref. 2) are believed to be typical for airplanes flown in basic aerobatic flight instruction operations.

The percentage of time flown in intervals of 2000 ft by airplanes in commuter operations is given in figure 8(h). Airplane 39, the heavier and slower of the two commuter airplanes, spent 89 percent of its flight time at altitudes below 4000 ft and only 11 percent between 4000 and 12 000 ft. Airplane 40 flew 50 percent of its time below 4000 ft, 49 percent between 4000 and 10 000 ft, and only 1 percent above 10 000 ft. The data illustrate the effects of flight duration on the altitude operating practices of commuter airplanes. Operations requiring short duration flights were flown in the lower altitude levels since climbs to higher altitudes would increase elapsed time between takeoff and destination and, in addition, would burn more fuel, thereby further increasing operating costs. Longer duration flights were made in the higher altitude levels to decrease operating costs (more efficient engine operation and higher true airspeeds) and to increase passenger comfort by flying in less turbulent air.

Figure 8(i) shows the percentage of time flown in altitude intervals of 2000 ft by airplane 41, a float-equipped airplane used in bush-type operations. As indicated in the figure, the majority (88 percent) of its flights were below 4000 ft. Two flights were made into the interval of 14 000 to 16 000 ft; however, flights above 10 000 ft were rare, accounting for only 1.0 percent of the total number of flights and 0.2 percent of the total flight time.

A comparison of altitude operating practices by the same airplane type used in different types of operations shows that more time is flown above 4000 ft by airplane type 4 when used in executive and commercial survey operations than when used in instructional operations. An exception to this is airplane type 17, flown in commercial survey and instructional operations. In this particular comparison the commercial survey airplane was flown on pipeline patrol and was never flown above 4000 ft, whereas the instructional airplane, based in Denver, Colorado, was seldom flown below 4000 ft. There appeared to be few differences between the altitude operating practices of airplanes used in instructional operations, type 12, and those used in personal operations. As a general comment, airplane altitude operating practices appear to be dictated by type of operation, and not by type of airplane.

CONCLUDING REMARKS

Detailed data have been presented on the flight durations, airspeed practices, and altitude usage for each of 95 general aviation airplanes involved in 9 different types of flight operations. These data complement acceleration data obtained from the same 95 airplanes and reported in NASA TM-84660. The combined data sets are intended to provide the general aviation airplane designer or analyst with a bank of data from which acceleration, flight duration, airspeed, and altitude information representative of present-day usage may be obtained.

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TABLE I.- AIRPLANE CHARACTERISTICS

(a) Twin-engine executive

Characteristic	Airplane					
	1	2	2A	3	4	5
Maximum gross weight, lb . . .	26 455	13 000	12 500	9000	4830	4800
Wing span, ft	53.5	35.8	35.8	45.9	36.0	37.0
Wing area, ft^2	441.0	231.8	231.8	279.7	175.0	207.0
Type propulsion	Turbojet	Turbojet	Turbojet	Turboprop	Piston	Piston
Power per engine, hp				500	260	250
Power per engine, lb	4200	2850	2850			
V_C at sea level, knots . . .	388	350	350	208	182	172
V_{NE} at sea level, knots . . .	437	300	358	234	215	216
V_D at sea level, knots . . .	485	400	400	260	239	240
n_m at V_C	2.50	4.40	4.40	3.40	3.80	3.80
$-n_m$ at V_C	1.00	1.76	1.76	1.68	1.52	1.52
n_g at V_C	4.40	3.44	3.44	3.10	2.97	3.10
$-n_g$ at V_C	2.40	1.44	1.44	1.10	0.97	1.10
VGH recorder used, knots . . .	0-460	0-460	0-460	0-350	0-240	0-240

TABLE I.- Continued

(b) Single-engine executive

Characteristic	Airplane								
	6	7	7A	7B	7C	8	8A	9	9A
Maximum gross weight, lb	4000	3400	3300	3125	2650	3200	2900	2650	2550
Wing span, ft	36.8	33.5	33.5	33.5	32.8	36.0	36.0	36.0	36.0
Wing area, ft^2	175.0	181.0	181.0	181.0	177.6	178.0	178.0	174.0	174.0
Type propulsion	Piston	Piston	Piston	Piston	Piston	Piston	Piston	Piston	Piston
Power per engine, hp	310	285	285	260	185	260	250	230	225
Power per engine, lb									
V_C at sea level, knots	165	165	165	161	139	156	156	139	139
V_{NE} at sea level, knots	198	195	195	195	175	197	197	162	160
V_D at sea level, knots	220	217	217	217	217	219	219	180	177
n_m at V_C	3.80	4.40	4.40	4.40	4.40	3.80	3.80	3.80	3.80
$-n_m$ at V_C	1.52	1.76	1.76	1.76	1.76	1.52	1.52	1.52	1.52
n_g at V_C	3.30	3.37	3.35	3.43	3.40	3.48	3.65	3.33	3.50
$-n_g$ at V_C	1.30	1.37	1.35	1.43	1.40	1.48	1.65	1.33	1.50
VGH recorder used, knots	0-240	0-240	0-240	0-240	0-240	0-240	0-240	0-240	0-240

TABLE I.- Continued

(c) Personal

Characteristic	Airplane					
	10	10A	11	12	12A	13
Maximum gross weight, lb	2740	2575	2475	2400	2200	2250
Wing span, ft	35.0	35.0	35.0	30.0	30.0	36.0
Wing area, ft^2	167.0	167.0	180.0	160.0	160.0	174.0
Type propulsion	Piston	Piston	Piston	Piston	Piston	Piston
Power per engine, hp	200	180	180	180	160	145
Power per engine, lb						
V_C at sea level, knots	152	130	122	122	122	122
V_{NE} at sea level, knots	175	164	153	148	148	139
V_D at sea level, knots	194	182	170	165	165	165
n_m at V_C	3.80	3.80	3.80	3.80	3.80	3.80
$-n_m$ at V_C	1.52	1.52	1.52	1.52	1.52	1.52
n_g at V_C	3.37	3.42	[a]3.41	3.30	3.30	3.39
$-n_g$ at V_C	1.37	1.42	[a]1.41	1.30	1.30	1.39
VGH recorder used, knots	0-240	0-240	0-240	0-240	0-240	0-240

[a]Calculated.

TABLE I.- Continued

(d) Instructional

Characteristic	Airplane							
	4A	14	14A	15	12B	16	17	18
Maximum gross weight, lb . . .	5300	2450	2200	2250	2150	1650	1500	1500
Wing span, ft	37.0	32.8	32.8	35.0	30.0	30.0	33.4	35.2
Wing area, ft^2	179.0	146.0	146.0	180.0	160.0	147.0	160.0	170.0
Type propulsion	Piston	Piston	Piston	Piston	Piston	Piston	Piston	Piston
Power per engine, hp	260	180	150	150	140	108	100	95
Power per engine, lb								
V_C at sea level, knots . . .	182	128	128	117	122	96	104	87
V_{NE} at sea level, knots . . .	223	162	162	148	148	129	137	117
V_D at sea level, knots . . .	248	180	180	164	165	143	152	130
n_m at V_C	3.80	4.40	4.40	3.60	3.80	4.40	4.40	4.52
$-n_m$ at V_C	1.52	1.90	1.90	1.52	1.52	1.76	1.76	1.20
n_g at V_C	2.84	[a]3.58	[a]3.80	[a]3.46	3.30	3.00	3.46	3.38
$-n_g$ at V_C	0.84	[a]1.58	[a]1.80	[a]1.46	1.30	1.00	1.46	1.38
VGH recorder used, knots . . .	0-240	0-240	0-240	0-240	0-240	0-240	0-240	0-240

[a]Calculated.

TABLE I.- Continued

(e) Commercial survey

Characteristic	Airplane													
	19	20	21	22	23	24	25	4[1]	26	6A	27	9B	17[1]	28
Maximum gross weight, lb	126 000	106 000	80 000	64 000	31 000	26 300	5400	4830	4300	3800	2950	2800	1500	1500
Wing span, ft	117.5	117.5	98.0	109.3	95.0	69.7	37.8	36.0	38.0	36.8	32.8	36.2	33.4	35.2
Wing area, ft^2	1463.0	1457.0	1000.0	1447.0	987.0	485.0	199.2	175.0	201.0	175.0	177.6	174.0	160.0	178.5
Type propulsion	Piston	Piston	Piston, turbojet	Piston	Piston	Piston	Piston	Piston	Piston	Piston	Piston	Piston	Piston	Piston
Power per engine, hp	3250	2400	3500	3250	1475	1525	285	260	210	285	225	230	100	95
Power per engine, lb			3400											
V_C at sea level, knots	269	260	175	NA	163	130	195	182	165	165	152	139	104	95
V_{NE} at sea level, knots	313	313	225	NA	188	336	223	215	202	195	219	167	137	129
V_D at sea level, knots	346	346	360	NA	209	373	247	239	215	217	243	186	152	143
n_m at V_C	2.50	2.50	3.00	3.00	2.50	3.00	4.20	3.80	3.80	3.80	6.00	3.80	4.40	4.40
$-n_m$ at V_C	1.00	1.00	1.00	1.00	1.00	1.00	3.00	1.52	1.52	1.52	3.00	1.52	1.76	1.76
n_g at V_C	[a]2.42	[a]2.79	[a]2.31	[a]2.81	[a]3.74	[a]3.16	3.20	2.97	3.16	3.41	3.26	3.33	3.46	3.59
$-n_g$ at V_C	[a]0.42	[a]0.79	[a]0.31	[a]0.81	[a]1.74	[a]1.16	1.20	0.97	1.16	1.41	1.26	1.33	1.46	1.59
VGH recorder used, knots	0-350	0-350	0-350	0-240	0-240	0-350	0-350	0-240	0-240	0-240	0-240	0-240	0-240	0-240

[a]Calculated.

TABLE I.- Continued

(f) Aerial application

Characteristic	Airplane											
	29	30	30A	31	32	33	33A	34	35	36	36A	37
Maximum gross weight, lb . .	[a]8200	[a]6900	6000	[a]6900	[a]6075	[a]6075	[a]6000	[a]4400	[a]4200	[a]4000	[a]3800	2900
Wing span, ft	44.4	44.4	42.6	45.1	Upper 35.7	Upper 35.7	Upper 35.7	38.8	41.1	40.7	40.4	36.2
Wing area, ft^2	326.6	326.6	312.4	270.6	328.0	326.0	326.0	225.0	208.7	202.0	202.0	183.0
Type propulsion	Turboprop	Piston	Piston	Piston	Turboprop	Piston	Piston	Piston	Piston	Piston	Piston	Piston
Power per engine, hp . . .	750	600	650	600	750	650	600	285	300	300	230	235
Power per engine, lb . . .												
V_C at sea level, knots . .	117	117	109	113	128	128	128	130	125	125	125	108
V_{NE} at sea level, knots . .	148	148	138	153	128	128	128	158	158	158	158	135
V_D at sea level, knots . .	164	164	153	170	142	142	142	175	175	175	175	151
n_m at V_C	3.80	3.80	3.80	3.80	4.20	4.20	4.20	3.80	3.80	3.80	3.80	3.80
$-n_m$ at V_C	1.52	1.90	1.90	1.90	1.00	1.00	1.00	1.52	1.52	1.52	1.52	1.52
n_g at V_C	[b]3.07	[b]2.78	[b]2.78	2.51	[b]2.60	[b]2.62	[b]2.62	3.25	3.31	3.31	3.31	2.83
$-n_g$ at V_C	[b]1.07	[b]0.78	[b]0.78	0.51	[b]0.60	[b]0.62	[b]0.62	1.25	1.31	1.31	1.31	0.83
VGH recorder used, knots . .	0-240	0-240	0-240	0-240	0-240	0-240	0-240	0-240	0-240	0-240	0-240	0-240

[a]Restricted category.
[b]Calculated.

TABLE I.- Concluded

(g) Aerobatic (h) Commuter (i) Float

Characteristic	Airplane	Airplane		Airplane
	38	39	40	41
Maximum gross weight, lb . .	1650	11 600	10 400	5090
Wing span, ft	33.4	65.0	45.9	48.0
Wing area, ft^2	165.0	420.0	279.7	250.0
Type propulsion	Piston	Turboprop	Turboprop	Piston
Power per engine, hp . . .	115	550	550	450
Power per engine, lb . . .				
V_C at sea level, knots . .	104	160	226	126
V_{NE} at sea level, knots . .	140	178	254	135
V_D at sea level, knots . .	156	225	282	152
n_m at V_C	[a]4.79	3.21	3.29	[a]3.69
$-n_m$ at V_C	[a]2.29	1.50	1.32	[a]1.48
n_g at V_C	[a]3.58	3.35	2.95	[a]2.79
$-n_g$ at V_C	[a]1.95	1.35	0.95	[a]0.79
VGH recorder used, knots . .	0-240	0-240	0-350	0-240

[a]Calculated.

TABLE II.- DATA SAMPLE

(a) Twin-engine executive operations

Parameter	Airplane										
	1	[a]1[1]	[a]1[2]	[a]1[3]	2	2A	[a]3	3[1]	4	5	5[1]
	Turbojet					Turboprop			Piston		
Number of flights	464	663	232	25	904	721	202	1290	1672	614	202
Flight time, hr	578	760	244	41	1335	597	213	1427	1254	563	263
Distance flown, n.mi.	219 656	250 447	88 624	15 338	493 292	216 991	39 856	281 300	206 478	86 977	41 586
Average operating altitude, ft	24 533	19 887	21 982	27 100	29 905	23 215	11 143	9914	4444	4695	7411
Average true airspeed, knots	380	329	363	372	369	363	187	197	165	154	158
Home base, state	FL	NY	NY	NY	IA	OH	KS	VA	WI	VA	CA

[a]Airplane used as flight demonstrator.

(b) Single-engine executive operations

Parameter	Airplane										
	6	7	7A	7B	7C	7C[1]	8	8A	8A[1]	9	9A
	Piston										
Number of flights	106	403	34	157	164	317	287	137	150	294	500
Flight time, hr	268	402	15	229	150	164	253	162	147	301	423
Distance flown, n.mi.	43 975	62 631	2241	34 419	18 351	19 182	38 678	21 481	20 540	37 137	55 059
Average operating altitude, ft	13 085	7520	4763	8047	4555	3722	7346	8348	5000	4539	7396
Average true airspeed, knots	164	156	145	150	122	117	153	133	140	123	130
Home base, state	NY	MT	VA	NM	DC	NY	ID	MT	TX	IN	ID

TABLE II.- Continued

(c) Personal operations

Parameter	Airplane										
	10	10[1]	10A	11	12	12[1]	12[2]	12[3]	12A	13	13[1]
	Piston										
Number of flights	155	195	264	317	47	373	127	286	53	931	140
Flight time, hr	224	175	265	131	30	199	81	193	34	782	123
Distance flown, n.mi.	31 563	22 436	34 231	12 596	3101	16 836	8222	19 192	3141	75 331	11 290
Average operating altitude, ft	6122	3513	5736	4116	2216	1174	2413	2792	1438	3004	6755
Average true airspeed, knots	141	128	129	96	103	85	101	100	92	96	92
Home base, state	TX	VA	CA	CA	FL	FL	FL	SC	FL	SC	UT

(d) Instructional operations

Parameter	Airplane										
	4A	14	14A	15	12B	12B[1]	12B[2]	16	17	18	18[1]
	Piston										
Number of flights	627	472	1433	525	524	508	1052	747	1057	190	2916
Flight time, hr	342	282	935	219	311	448	754	494	812	96	911
Distance flown, n.mi.	46 214	23 994	80 902	19 057	25 703	40 524	64 872	37 420	65 991	6962	68 764
Average operating altitude, ft	2009	1704	2380	2720	2500	2387	2172	1506	6905	1999	2030
Average true airspeed, knots	135	85	87	87	83	90	86	76	81	73	75
Home base, state	FL	IL	OH	TX	NB	IN	IL	SC	CO	CA	CA

TABLE II.- Continued

(e) Commercial survey operations

Parameter	Airplane										
	19	19[1]	20	20[1]	21	22	23	24	24[1]	24[2]	24[3]
	Piston				T-jet & Pstn	Piston					
Number of flights	28	28	343	391	304	61	196	248	168	126	120
Flight time, hr	24	24	285	328	305	29	222	78	92	67	67
Distance flown, n.mi.	4209	4245	50 316	58 213	53 440	4052	31 242	11 969	13 597	10 222	10 300
Average operating altitude, ft	4952	5165	5015	5368	5262	2960	8162	2907	2922	2835	3355
Average true airspeed, knots	178	180	176	178	175	141	141	153	147	152	153
Home base, state	OR	AZ	OR	OR	OR	CA	ID	CA	CA	CA	CA

Parameter	Airplane									
	24[4]	24[5]	25	4[1]	26	6A	27	9B	17[1]	28
	Piston									
Number of flights	171	155	169	67	612	277	195	316	492	211
Flight time, hr	101	85	246	79	901	545	253	740	1258	888
Distance flown, n.mi.	16 205	12 302	37 921	12 339	126 142	82 899	31 187	82 334	111 407	54 312
Average operating altitude, ft	2855	1954	7478	6908	2870	6080	5059	6895	1150	1706
Average true airspeed, knots	161	144	154	156	140	152	123	111	89	61
Home base, state	CA	CA	NM	ID	NE	WY	OR	OR	OK	VA

TABLE II.- Continued

(f) Aerial application operations

Parameter	Airplane												
	29	29[1]	30	30[1]	30[2]	30A	31	32	32[1]	32[2]	33	33[1]	33A
	Turboprop		Piston					Turboprop			Piston		
Number of flights	1164	424	605	58	546	2873	507	760	221	1446	594	467	247
Flight time, hr	339	298	127	47	140	782	174	100	54	202	351	124	45
Distance flown, n.mi.	39 219	30 818	11 838	4437	12 459	67 855	16 831	9017	5234	17 527	29 909	10 689	3438
Average operating altitude, ft	165	193	840	2369	664	1148	2993	87	953	536	492	11	148
Average true airspeed, knots	116	104	93	95	89	87	97	90	97	89	85	87	77
Home base, state	AL	TX	OR	NE	OR	AZ	AZ	TX	MI	TX	VA	TX	CA

Parameter	Airplane												
	33A[1]	33A[2]	34	34[1]	34[2]	34[3]	35	35[1]	35[2]	36	36A	37	37[1]
	Piston												
Number of flights	230	107	156	337	347	731	1311	652	342	1195	180	829	488
Flight time, hr	23	13	31	203	187	322	357	392	137	208	72	175	344
Distance flown, n.mi.	1815	1114	2888	18 166	15 642	29 184	33 591	39 317	13 952	18 838	6071	14 032	25 087
Average operating altitude, ft	83	144	2377	1295	658	193	4982	1351	3770	97	929	170	2691
Average true airspeed, knots	80	87	93	90	84	91	94	100	102	91	85	80	73
Home base, state	TX	CA	AZ	TX	FL	FL	MT	TX	TX	TX	AZ	FL	TX

TABLE II.- Concluded

Parameter	(g) Aerobatic operations	(h) Commuter operations		(i) Float operations
	Airplane	Airplane		Airplane
	38	39	40	41
	Piston	Turboprop		Piston
Number of flights	335	7378	5143	1623
Flight time, hr	170	2056	2684	885
Distance flown, n.mi.	13 723	274 012	508 180	89 722
Average operating altitude, ft	1659	2324	4278	2505
Average true airspeed, knots	81	133	189	101
Home base, state	VA	CA	PA	WA

TABLE III.- NUMBER OF FLIGHTS OF A GIVEN DURATION FLOWN BY INDIVIDUAL AIRPLANES IN SPECIFIED TYPES OF OPERATIONS

(a) Twin-engine executive operations

Flight duration, min	Flights per airplane -										
	1	$^{a}1^{1}$	$^{a}1^{2}$	$^{a}1^{3}$	2	2A	$^{a}3$	3^{1}	4	5	5^{1}
	Turbojet						Turboprop		Piston		
0 to 15	11	86	36	0	18	116	28	79	355	49	15
15 to 30	46	98	35	2	49	158	39	114	310	97	15
30 to 45	90	101	31	1	112	92	29	171	315	141	23
45 to 60	64	89	23	3	126	140	33	372	223	117	9
60 to 75	56	49	23	4	87	87	13	136	195	81	40
75 to 90	47	42	18	3	53	29	15	69	122	37	26
90 to 105	33	30	18	3	76	21	8	83	60	27	7
105 to 120	29	26	14	2	111	26	9	147	33	25	32
120 to 135	27	39	13	2	115	25	3	63	17	14	19
135 to 150	36	30	9	2	77	13	6	22	8	9	10
150 to 165	11	32	6	1	53	8	7	11	4	6	3
165 to 180	9	17	1	2	20	2	2	9	2	6	1
180 to 195	2	13	4		6	3	0	7	3	2	0
195 to 210	2	7	1		1	0	3	4	6	1	0
210 to 225	1	4				1	1	2	9	1	1
225 to 240							3	1	2	0	0
240 to 255							1		3	1	1
255 to 270							1		3		
270 to 285							0		0		
285 to 300							1		2		

[a]Demonstrator.

TABLE III.- Continued

(b) Single-engine executive operations

Flight duration, min	Flights per airplane -										
	6	7	7A	7B	7C	7C[1]	8	8A	8A[1]	9	9A
	Piston										
0 to 15	4	23	5	7	12	36	41	1	7	76	60
15 to 30	4	93	17	15	41	179	38	16	23	45	94
30 to 45	7	79	9	14	26	46	90	39	30	35	93
45 to 60	8	51	2	21	24	26	28	14	19	34	88
60 to 75	1	51	0	15	28	14	28	18	28	16	57
75 to 90	3	28	1	26	10	5	15	12	20	7	54
90 to 105	2	20		14	5	1	11	10	5	12	20
105 to 120	3	19		8	3	1	12	5	11	6	6
120 to 135	4	12		12	4	3	9	4	3	14	8
135 to 150	5	9		3	3	3	3	5	2	10	13
150 to 165	7	5		3	4	1	5	4	1	14	3
165 to 180	13	3		6	0	1	3	5	1	10	2
180 to 195	9	1		2	2	0	1	1		8	1
195 to 210	16	0		3	1	0	0	1		7	1
210 to 225	5	3		1	0	0	1	0			
225 to 240	5	2		2	1	0	1	1			
240 to 255	2	0		3		1	0	1			
255 to 270	4	2		0			0				
270 to 285	2	0		1			0				
285 to 300	1	1		1			1				
300 to 315	1	0									
315 to 330		1									

TABLE III.- Continued

(c) Personal operations

Flight duration, min	Flights per airplane -										
	10	10[1]	10A	11	12	12[1]	12[2]	12[3]	12A	13	13[1]
	Piston										
0 to 15	3	34	39	175	12	98	39	53	9	145	21
15 to 30	16	36	51	52	13	101	33	70	17	200	30
30 to 45	16	40	57	33	10	94	24	47	8	193	20
45 to 60	11	21	26	18	6	45	9	66	13	147	27
60 to 75	23	15	23	15	2	12	5	20	2	80	16
75 to 90	30	12	15	7	1	12	4	15	1	38	9
90 to 105	9	18	11	9	0	6	2	6	1	29	2
105 to 120	10	3	7	1	1	3	3	5	0	25	4
120 to 135	11	2	7	3	0	0	3	1	2	19	2
135 to 150	4	2	3	2	1	0	1	0		11	3
150 to 165	6	3	5	1	0	2	1	0		14	1
165 to 180	5	2	2	1	0		0	1		4	0
180 to 195	7	0	6		0		2	0		7	1
195 to 210	2	3	3		0		0	0		4	2
210 to 225	1	1	3		0		0	0		4	2
225 to 240	1	2	2		1		0	0		3	
240 to 255		0	0				0	2		5	
255 to 270		1	3				1			1	
270 to 285			0							1	
285 to 300			0							0	
300 to 315			0							1	
315 to 330			1								

TABLE III.- Continued

(d) Instructional operations

Flight duration, min	Flights per airplane -										
	4A	14	14A	15	12B	12B[1]	12B[2]	16	17	18	18[1]
	Piston										
0 to 15	187	101	209	237	114	37	122	89	200	35	1785
15 to 30	131	101	300	103	106	47	178	189	168	55	408
30 to 45	120	101	405	78	121	98	216	211	167	65	359
45 to 60	117	104	327	68	130	156	343	150	184	29	209
60 to 75	48	43	94	24	36	90	136	59	180	4	81
75 to 90	12	14	45	11	8	37	33	23	80	2	32
90 to 105	0	3	27	2	3	22	15	12	37		32
105 to 120	8	2	11	1	3	9	4	7	20		6
120 to 135	0	3	9	1	0	5	3	5	8		2
135 to 150	0		3		1	4	0	3	2		0
150 to 165	1		0		1	3	0		5		2
165 to 180	1		1		0		2		3		
180 to 195	0		1		1				0		
195 to 210	0		0						3		
210 to 225	1		0								
225 to 240	0		0								
240 to 255	1		1								

TABLE III.- Continued

(e) Commercial survey operations

Flight duration, min	Flights per airplane -																				
	19	19[1]	20	20[1]	21	22	23	24	24[1]	24[2]	24[3]	24[4]	24[5]	25	4[1]	26	6A	27	9B	17[1]	28
	Piston				T-jet & Pstn	Piston															
0 to 15	0	1	11	13	9	9	13	108	35	7	10	11	15	15	10	20	5	17	2	18	10
15 to 30	4	2	65	82	44	24	19	116	51	61	46	55	78	24	9	46	7	22	13	28	5
30 to 45	7	8	82	107	63	20	45	11	39	38	36	68	32	21	9	59	21	21	3	22	5
45 to 60	11	7	103	86	98	6	27	5	29	13	18	25	20	22	11	37	34	29	6	30	5
60 to 75	3	8	47	49	42	2	25	7	4	4	6	10	5	12	6	87	16	19	8	35	1
75 to 90	0	2	16	18	14		10	0	6	1	4	1	1	8	1	76	15	14	6	41	6
90 to 105	3		5	18	11		20	0	3	1		1	1	14	6	92	33	17	8	27	4
105 to 120			4	6	3		8	1	0	1			2	13	2	69	24	8	15	16	8
120 to 135			1	2	4		9		0				0	7	3	36	24	17	50	12	9
135 to 150			1	5	3		10		1				0	3	2	20	10	9	57	11	7
150 to 165			2	0	0		1						1	6	3	23	10	5	53	8	4
165 to 180			2	1	1		5							5	0	21	17	4	49	8	7
180 to 195			0	0	1		1							1	1	11	22	9	36	16	7
195 to 210			0	1	1		0							3	0	9	10	4	4	19	4
210 to 225			1	1	0		0							3	1	3	14		1	44	5
225 to 240			3	0	2		2							3	2	2	11		2	66	5
240 to 255				0	1		0							0	1	0	1		1	35	9
255 to 270				0	2		0							1		0	2		0	16	11
270 to 285				1	1		1							5		1	1		1	12	5
285 to 300				0	1									0					0	13	10
300 to 315				0	1									1					0	10	7
315 to 330				0	1									0					0	3	8
330 to 345				0	0									2					1	2	5
345 to 360				0	0																9
360 to 375				0	0																6
375 to 390				0	0																6
390 to 405				0	0																4
405 to 420				1	0																6
420 to 435					0																4
435 to 450					1																8
450 to 465																					9
465 to 480																					6
480 to 495																					4
495 to 510																					1
510 to 525																					1
525 to 540																					

TABLE III.- Continued

(f) Aerial application operations

Flight duration, min	Flights per airplane -												
	29	29[1]	30	30[1]	30[2]	30A	31	32	32[1]	32[2]	33	33[1]	33A
	Turboprop		Piston					Turboprop			Piston		
0 to 15	525	24	417	8	363	1509	78	693	129	1312	41	277	183
15 to 30	511	55	171	8	149	1115	380	58	71	113	195	119	61
30 to 45	114	172	16	12	26	190	48	7	18	12	203	53	3
45 to 60	13	108	1	9	2	51	1	1	2	5	108	14	
60 to 75	1	43		9	4	8		1	1	2	34	3	
75 to 90		18		7	2					2	8	1	
90 to 105		3		5							3		
105 to 120		1									2		
120 to 135													

TABLE III.- Continued

(f) Concluded

Flight duration, min	Flights per airplane -												
	33A[1]	33A[2]	34	34[1]	34[2]	34[3]	35	35[1]	35[2]	36	36A	37	37[1]
	Piston												
0 to 15	224	104	118	57	128	126	768	142	71	972	22	589	62
15 to 30	6	3	25	91	103	398	382	218	182	181	122	195	89
30 to 45			9	72	26	136	87	93	66	29	28	37	117
45 to 60			2	68	37	45	38	70	17	11	6	4	117
60 to 75			2	34	19	7	22	64	3	2	1	3	60
75 to 90				14	10	9	4	33	1		1	1	32
90 to 105				0	5	5	4	13	1				11
105 to 120				0	7	2	4	12	1				
120 to 135				1	9	1	1	5					
135 to 150					2	0	1	2					
150 to 165					0	1							
165 to 180					0	1							
180 to 195					0								
195 to 210					0								
210 to 225					0								
225 to 240					0								
240 to 255					0								
255 to 270					0								
270 to 285					1								

TABLE III.- Concluded

(g) Aerobatic operations (h) Commuter operations (i) Float operations

Flight duration, min	Flights per airplane -	Flights per airplane -		Flights per airplane -
	38	39	40	41
	Piston	Turboprop		Piston
0 to 15	48	2763	585	722
15 to 30	140	4241	2145	136
30 to 45	90	287	1285	266
45 to 60	39	73	872	134
60 to 75	10	9	222	237
75 to 90	5	2	27	89
90 to 105	2	1	5	23
105 to 120	1	0	2	7
120 to 135		2		2
135 to 150				4
150 to 165				2
165 to 180				0
180 to 195				1

TABLE IV.- HOURS OF FLIGHT IN VARIOUS AIRSPEED INTERVALS BY INDIVIDUAL AIRPLANES FLOWN IN SPECIFIED TYPES OF OPERATIONS

(a) Twin-engine executive operations

IAS, knots	Flight hr per airplane -					
	1	$a_1$1	$a_1$2	$a_1$3	2	2A
	Turbojet					
0 to 20						
20 to 40						
40 to 60						
60 to 80						
80 to 100		0.18	0.03		1.50	0.43
100 to 120	0.78	7.90	1.07	0.18	8.98	3.55
120 to 140	13.03	42.17	7.82	0.48	23.00	11.80
140 to 160	11.57	43.88	7.93	0.38	30.68	22.52
160 to 180	11.50	37.85	6.42	0.57	46.90	19.33
180 to 200	14.30	37.32	9.13	1.20	135.00	21.68
200 to 220	29.08	67.83	12.63	4.55	396.07	55.27
220 to 240	95.82	150.45	25.97	15.82	360.32	137.78
240 to 260	127.70	138.45	41.38	8.83	109.37	137.68
260 to 280	121.57	93.53	59.83	3.32	141.45	59.87
280 to 300	71.72	66.03	47.55	2.52	77.70	46.42
300 to 320	32.95	39.45	17.63	1.62	2.82	38.23
320 to 340	29.35	24.82	4.35	1.42	1.48	28.72
340 to 360	17.93	9.93	1.88	0.38		13.20
360 to 380	0.47	0.45	0.28			0.65
380 to 400			0.07			

[a]Demonstrator.

TABLE IV.- Continued

(a) Concluded

IAS, knots	Flight hr per airplane -				
	[a]3	3^1	4	5	5^1
	Turboprop		Piston		
0 to 10					
10 to 20					
20 to 30					
30 to 40					
40 to 50					
50 to 60				0.28	0.02
60 to 70			0.68	0.97	0.22
70 to 80	0.08	0.18	5.08	2.25	1.95
80 to 90	1.45	1.12	15.22	4.12	2.88
90 to 100	2.52	2.10	36.35	7.93	3.70
100 to 110	7.23	7.27	55.52	17.13	6.73
110 to 120	9.22	27.55	65.40	29.18	14.58
120 to 130	11.12	60.73	56.98	30.03	24.92
130 to 140	12.57	97.30	50.65	44.25	52.58
140 to 150	22.97	97.97	60.77	190.50	70.77
150 to 160	39.13	129.70	158.42	185.13	55.27
160 to 170	43.52	234.98	437.05	46.02	24.98
170 to 180	32.50	256.13	268.92	5.02	3.95
180 to 190	15.05	200.12	39.28	0.25	0.73
190 to 200	8.92	179.22	3.25		0.15
200 to 210	5.92	110.95	0.08		
210 to 220	1.00	20.92			
220 to 230	0.05	0.35			
230 to 240		0.08			

[a]Demonstrator.

TABLE IV.- Continued

(b) Single-engine executive operations

IAS, knots	Flight hr per airplane -										
	6	7	7A	7B	7C	7C[1]	8	8A	8A[1]	9	9A
	Piston										
0 to 10											
10 to 20											
20 to 30											
30 to 40											
40 to 50											
50 to 60		0.25			0.05	0.40	0.13	0.15	0.02	0.57	1.22
60 to 70		1.13	0.12	0.42	0.40	2.65	0.65	0.50	0.22	1.38	4.13
70 to 80	0.27	2.58	0.27	0.62	2.18	7.80	1.20	3.15	0.72	4.00	11.55
80 to 90	1.22	6.12	0.17	2.25	7.98	11.80	4.52	8.52	1.47	10.05	16.72
90 to 100	1.62	9.95	0.65	9.30	13.32	25.52	12.33	8.20	5.40	18.87	20.82
100 to 110	10.70	15.68	0.92	12.77	6.85	21.70	14.53	11.75	10.28	25.92	42.63
110 to 120	29.10	16.02	1.42	8.02	69.32	28.12	13.97	52.57	10.22	114.47	116.32
120 to 130	37.93	22.72	1.03	29.33	44.17	48.58	18.93	56.42	28.12	119.37	154.05
130 to 140	99.65	87.90	1.52	81.50	4.95	16.27	69.18	17.58	59.43	6.05	50.85
140 to 150	54.92	127.48	6.38	70.85	0.60	0.80	63.53	2.97	27.87	0.05	4.35
150 to 160	22.60	89.75	2.62	12.33		0.05	34.78	0.18	3.27	0.02	0.33
160 to 170	9.42	21.02	0.33	1.33			16.72		0.17		0.02
170 to 180	0.12	1.03	0.02	0.08			2.73				
180 to 190	0.07										
190 to 200	0.02										

TABLE IV.- Continued

(c) Personal operations

IAS, knots	Flight hr per airplane -										
	10	10[1]	10A	11	12	12[1]	12[2]	12[3]	12A	13	13[1]
	Piston										
0 to 10											
10 to 20											
20 to 30											
30 to 40											
40 to 50						0.48	0.05	0.23			0.47
50 to 60	0.15	0.92	0.57	1.23	0.12	4.67	0.87	1.43	0.35	5.02	2.52
60 to 70	0.28	3.45	2.72	14.28	0.47	14.77	1.57	3.27	0.55	33.28	11.65
70 to 80	1.85	9.78	6.68	20.85	1.33	46.38	4.78	14.35	3.67	79.07	26.68
80 to 90	2.97	15.13	11.48	24.62	2.42	78.03	11.40	35.78	9.33	158.77	49.97
90 to 100	10.55	13.63	18.08	49.07	6.78	48.62	24.67	61.67	16.32	354.88	29.08
100 to 110	14.33	11.37	21.73	18.75	17.70	5.23	28.10	61.58	3.73	138.45	2.35
110 to 120	7.92	9.90	43.10	1.97	1.27	0.42	9.25	13.78	0.08	11.77	0.08
120 to 130	46.32	20.03	107.73	0.28		0.03	0.67	0.45		0.60	
130 to 140	113.33	45.23	46.75	0.02			0.02	0.03			
140 to 150	24.75	39.88	5.78								
150 to 160	2.02	5.62	0.60								
160 to 170		0.18									

TABLE IV.- Continued

(d) Instructional operations

IAS, knots	Flight hr per airplane -										
	4A	14	14A	15	12B	12B[1]	12B[2]	16	17	18	18[1]
	Piston										
0 to 10											
10 to 20											
20 to 30					0.03	0.15			1.98		0.15
30 to 40		0.62	0.13	0.40	1.87	2.43	1.05	1.37	8.15	0.37	2.15
40 to 50		3.43	5.98	1.95	6.02	7.47	10.12	8.00	15.25	4.97	12.52
50 to 60		8.28	19.78	6.82	14.97	10.78	25.87	17.75	46.88	7.63	42.57
60 to 70	6.85	37.43	79.92	27.83	55.90	32.23	116.88	102.42	207.43	32.85	261.32
70 to 80	6.42	80.50	274.55	48.18	61.33	97.17	176.45	248.23	309.13	30.03	394.05
80 to 90	9.20	59.83	243.62	49.43	94.18	75.45	129.58	113.90	198.43	18.40	176.47
90 to 100	20.65	61.62	250.12	67.55	64.37	120.00	196.07	2.30	23.77	1.43	20.47
100 to 110	39.65	27.30	54.83	16.03	11.08	91.17	87.82	0.02	0.82	0.10	1.28
110 to 120	46.43	2.40	5.25	0.90	0.87	10.52	9.47		0.10	0.02	0.10
120 to 130	48.07	0.17	0.88	0.03	0.03	0.67	0.28		0.03		0.02
130 to 140	29.37	0.03	0.05			0.08	0.13				
140 to 150	25.87	0.00									
150 to 160	40.50	0.02									
160 to 170	49.37	0.02									
170 to 180	16.83										
180 to 190	2.45										
190 to 200	0.33										

TABLE IV.- Continued

(e) Commercial survey operations

IAS, knots	Flight hr per airplane -										
	19	19^1	20	20^1	21	22	23	24	24^1	24^2	24^3
	Piston				T-jet & Pstn	Piston					
0 to 10											
10 to 20											
20 to 30											
30 to 40											
40 to 50											
50 to 60											
60 to 70								0.03	0.02	0.02	
70 to 80							1.08	0.10	0.08	0.12	0.05
80 to 90		0.07	0.03	0.08	0.15	0.05	7.60	0.77	0.42	0.77	0.27
90 to 100	0.03	0.08	0.60	0.78	0.47	0.20	13.87	1.22	1.87	1.68	1.48
100 to 110	0.13	0.18	1.65	2.28	1.52	1.20	22.45	2.07	3.15	2.50	2.13
110 to 120	0.48	0.55	5.02	6.58	4.48	2.53	30.58	3.58	7.97	3.13	3.10
120 to 130	1.32	1.53	15.00	16.88	9.23	6.07	53.33	6.20	14.25	8.42	4.13
130 to 140	1.62	1.48	21.65	26.60	14.87	7.58	58.87	8.70	15.12	8.03	8.88
140 to 150	1.88	1.37	34.87	38.93	37.18	8.23	29.58	12.67	13.23	5.43	13.60
150 to 160	2.47	1.50	49.45	56.03	94.47	2.63	4.53	23.37	20.78	14.33	20.58
160 to 170	5.12	3.40	31.97	40.72	98.05	0.28	0.30	15.15	11.93	21.77	11.63
170 to 180	4.17	5.92	49.22	47.87	33.73	0.02	0.03	3.38	2.62	1.07	1.32
180 to 190	4.27	5.35	45.33	47.85	7.65	0.02		0.45	0.58	0.07	0.12
190 to 200	1.97	1.82	22.25	29.33	1.88			0.22	0.13		
200 to 210	0.23	0.30	5.80	11.68	0.62			0.07	0.12		
210 to 220	0.02	0.05	1.68	1.78	0.27			0.00	0.00		
220 to 230			0.48	0.42	0.13			0.02	0.02		
230 to 240			0.10		0.08			0.00			
240 to 250			0.02		0.18			0.02			
250 to 260					0.02						
260 to 270					0.00						
270 to 280					0.00						
280 to 290					0.00						
290 to 300					0.00						
300 to 310					0.00						
310 to 320					0.02						

TABLE IV.- Continued

(e) Concluded

IAS, knots	Flight hr per airplane -									
	24[4]	24[5]	25	4[1]	26	6A	27	9B	17[1]	28
	Piston									
0 to 10										
10 to 20										
20 to 30										
30 to 40										
40 to 50									1.00	48.93
50 to 60					0.37	0.35	0.17		4.72	418.57
60 to 70					1.13	0.72	0.57	3.58	22.90	359.20
70 to 80		0.13	0.23	0.13	5.73	2.02	4.63	31.27	124.95	58.88
80 to 90	0.08	0.43	2.37	0.48	7.72	4.53	21.13	49.97	669.55	2.57
90 to 100	0.70	1.53	11.48	1.12	9.22	5.82	35.98	228.85	423.77	0.22
100 to 110	2.27	2.70	31.50	2.50	17.87	14.32	43.25	340.55	9.17	0.03
110 to 120	4.35	6.87	31.32	3.80	42.03	23.35	44.57	78.67	1.20	
120 to 130	9.25	11.47	27.32	7.73	191.13	48.68	48.20	6.53	0.58	
130 to 140	14.30	16.53	15.85	19.38	325.07	144.17	35.03	0.55		
140 to 150	12.10	18.95	18.62	22.97	235.07	196.52	13.08	0.03		
150 to 160	13.28	19.43	49.28	15.05	58.02	92.77	4.63			
160 to 170	15.75	5.90	46.37	5.37	6.92	10.92	1.22			
170 to 180	15.75	1.40	10.73	0.75	0.58	0.80	0.20			
180 to 190	7.58	0.13	1.23	0.05		0.08	0.08			
190 to 200	3.17		0.10				0.02			
200 to 210	1.53									
210 to 220	0.42									
220 to 230	0.13									
230 to 240	0.02									

TABLE IV.- Continued

(f) Aerial application operations

IAS, knots	Flight hr per airplane -												
	29	29[1]	30	30[1]	30[2]	30A	31	32	32[1]	32[2]	33	33[1]	33A
	Turboprop		Piston					Turboprop			Piston		
0 to 10													
10 to 20													
20 to 30													
30 to 40													
40 to 50						0.38		0.04	0.17	0.73	0.43		
50 to 60	0.40	0.28	0.68		0.55	6.45	0.05	0.57	0.18	4.38	1.32	0.18	0.45
60 to 70	1.92	1.47	2.35	0.15	1.98	40.57	0.70	3.27	3.77	12.88	18.12	3.43	10.72
70 to 80	2.85	8.05	11.08	5.63	21.93	228.80	10.13	12.97	7.25	34.48	100.37	21.97	14.72
80 to 90	7.92	30.65	38.97	13.00	59.40	279.17	51.90	27.63	8.40	57.32	134.65	49.98	16.35
90 to 100	25.57	55.87	43.65	18.53	45.08	159.43	76.03	40.40	10.68	62.05	68.37	42.77	2.30
100 to 110	54.78	107.10	25.85	9.22	11.22	40.08	32.67	15.42	12.15	26.62	21.32	5.08	0.02
110 to 120	93.90	87.22	4.23	0.15	0.22	25.28	2.05	0.15	9.52	2.63	5.95	0.15	
120 to 130	128.05	6.97	0.13			1.50	0.03		2.02	0.47	0.73		
130 to 140	23.18	0.07							0.03	0.05	0.03		
140 to 150	0.22										0.02		

TABLE IV.- Continued

(f) Concluded

IAS, knots	Flight hr per airplane -												
	33A[1]	33A[2]	34	34[1]	34[2]	34[3]	35	35[1]	35[2]	36	36A	37	37[1]
	Piston												
0 to 10													
10 to 20													
20 to 30													
30 to 40													
40 to 50							0.17	0.08					0.58
50 to 60	0.03	0.07	0.12	0.42	0.93	0.40	1.57	0.53	0.22	0.48	0.15	1.60	19.46
60 to 70	4.27	0.97	1.40	5.95	10.65	1.93	14.52	2.75	0.83	2.35	0.77	11.03	140.40
70 to 80	6.87	2.42	5.10	34.33	48.12	30.58	66.75	13.80	4.15	19.62	20.43	74.90	173.15
80 to 90	8.05	3.55	7.82	70.65	95.07	102.35	117.45	64.63	29.00	71.37	36.60	76.48	10.17
90 to 100	3.13	4.50	10.12	73.87	29.95	164.38	124.28	105.52	53.4	83.33	13.42	10.50	0.62
100 to 110	0.33	1.23	6.07	17.03	2.05	21.90	29.98	175.52	44.08	30.17	0.17	0.27	
110 to 120	0.02	0.05	0.40	0.37	0.10	0.33	1.85	27.88	5.28	0.32		0.15	
120 to 130			0.02	0.03			0.10	1.10	0.35			0.08	
130 to 140								0.02	0.02				

TABLE IV.- Concluded

(g) Aerobatic operations (h) Commuter operations (i) Float operations

IAS, knots	Flight hr per airplane -	Flight hr per airplane -		Flight hr per airplane -
	38	39	40	41
	Piston	Turboprop		Piston
0 to 10				
10 to 20	0.07			
20 to 30	0.23			
30 to 40	0.80			
40 to 50	2.20			0.85
50 to 60	13.72	1.73		3.55
60 to 70	42.85	11.62		14.27
70 to 80	34.13	32.50		47.18
80 to 90	33.27	70.95	4.85	89.37
90 to 100	26.95	136.15	16.12	307.23
100 to 110	10.87	194.52	27.08	361.75
110 to 120	3.37	158.98	57.65	55.35
120 to 130	1.48	178.98	117.63	4.82
130 to 140	0.40	485.05	129.73	0.18
140 to 150	0.02	590.92	131.38	0.05
150 to 160		152.28	143.78	
160 to 170		37.20	146.12	
170 to 180		4.53	217.87	
180 to 190		0.28	509.52	
190 to 200		0.02	816.53	
200 to 210			304.50	
210 to 220			57.52	
220 to 230			3.40	
230 to 240			0.80	

TABLE V.- HOURS OF FLIGHT IN VARIOUS ALTITUDE INTERVALS BY INDIVIDUAL AIRPLANES FLOWN IN SPECIFIED TYPES OF OPERATIONS

(a) Twin-engine executive operations

Altitude, ft	Flight hr per airplane -					
	1	$^{a}1$	$^{a}2$	$^{a}3$	2	2A
	Turbojet					
0 to 5 000	69.98	177.97	43.12	3.75	139.27	136.95
5 000 to 10 000	41.35	74.38	19.97	2.25	98.95	51.90
10 000 to 15 000	35.77	66.65	15.28	2.00	71.30	34.07
15 000 to 20 000	35.08	49.15	17.25	1.75	66.73	33.08
20 000 to 25 000	47.63	58.87	21.37	2.65	63.27	39.68
25 000 to 30 000	64.08	58.93	26.35	4.13	64.97	29.28
30 000 to 35 000	162.97	145.90	64.58	11.55	67.95	42.83
35 000 to 40 000	119.35	124.53	35.07	13.18	168.58	117.20
40 000 to 45 000	1.70	3.87	1.00		594.25	112.13

[a]Demonstrator.

TABLE V.- Continued

(a) Concluded

Altitude, ft	Flight hr per airplane -				
	[a]3	3[1]	4	5	5[1]
	Turboprop		Piston		
0 to 2 000	21.97	84.45	192.77	103.08	13.75
2 000 to 4 000	20.85	123.95	391.98	150.60	23.45
4 000 to 6 000	11.53	117.35	335.28	116.80	30.18
6 000 to 8 000	12.43	158.90	238.60	110.93	57.73
8 000 to 10 000	15.57	194.22	83.78	74.32	103.67
10 000 to 12 000	22.80	220.43	8.84	7.20	28.48
12 000 to 14 000	23.25	224.90	2.37	0.13	5.28
14 000 to 16 000	34.60	183.47	0.38		0.88
16 000 to 18 000	23.65	64.78			
18 000 to 20 000	19.58	48.65			
20 000 to 22 000	6.62	5.57			
22 000 to 24 000	0.38				

[a]Demonstrator.

TABLE V.- Continued

(b) Single-engine executive operations

Altitude, ft	Flight hr per airplane -										
	6	7	7A	7B	7C	7C[1]	8	8A	8A[1]	9	9A
	Piston										
0 to 2 000	9.65	1.38	0.77	4.53	30.82	32.73	3.55	0.43	22.93	47.75	
2 000 to 4 000	18.58	23.83	4.37	11.37	42.28	81.95	20.12	4.55	39.87	103.97	12.80
4 000 to 6 000	15.57	95.00	6.08	24.42	24.78	23.63	52.03	21.22	33.87	64.12	118.93
6 000 to 8 000	16.68	107.45	3.98	58.73	33.00	12.18	68.25	40.73	20.60	47.38	129.00
8 000 to 10 000	20.12	105.82	0.23	87.12	13.83	7.62	75.13	54.58	24.63	24.50	103.42
10 000 to 12 000	11.12	52.83		37.02	5.10	5.13	29.58	35.62	4.33	12.88	51.62
12 000 to 14 000	32.37	12.80		5.22		0.43	4.42	4.83	0.93	0.13	7.18
14 000 to 16 000	50.67	2.52		0.40			0.13	0.02			
16 000 to 18 000	41.08										
18 000 to 20 000	29.02										
20 000 to 22 000	21.68										
22 000 to 24 000	1.07										

TABLE V.- Continued

(c) Personal operations

Altitude, ft	Flight hr per airplane -										
	10	10[1]	10A	11	12	12[1]	12[2]	12[3]	12A	13	13[1]
	Piston										
0 to 2 000	12.23	58.77	40.77	32.23	15.47	175.12	40.75	77.15	27.92	313.12	0.22
2 000 to 4 000	35.52	47.85	42.07	39.73	9.63	17.98	19.88	74.68	5.13	272.08	2.75
4 000 to 6 000	43.72	37.30	48.50	30.22	4.82	3.45	19.18	25.62	0.85	103.38	50.10
6 000 to 8 000	96.03	23.25	65.27	19.25	0.18	1.35	0.90	12.22	0.13	58.07	35.80
8 000 to 10 000	25.60	7.32	47.53	5.83		0.72	0.65	2.87		30.38	23.80
10 000 to 12 000	9.38	0.65	19.88	3.80				0.05		4.68	10.13
12 000 to 14 000	1.90		0.68							0.12	
14 000 to 16 000	0.08		0.18								
16 000 to 18 000			0.18								
18 000 to 20 000			0.17								
20 000 to 22 000											
22 000 to 24 000											

TABLE V.- Continued

(d) Instructional operations

Altitude, ft	Flight hr per airplane -										
	4A	14	14A	15	12B	12B[1]	12B[2]	16	17	18	18[1]
	Piston										
0 to 2 000	204.02	183.40	404.08	65.27	124.25	197.02	395.95	348.20	0.05	52.48	505.30
2 000 to 4 000	105.63	76.05	438.52	127.13	156.47	199.83	301.47	137.03	1.07	36.20	310.93
4 000 to 6 000	20.48	17.30	80.10	20.48	25.82	42.02	51.67	6.23	182.43	6.25	72.87
6 000 to 8 000	4.23	4.15	11.87	6.17	3.98	6.70	3.68	2.10	490.30	0.88	19.92
8 000 to 10 000	7.42	0.42	0.55	0.12	0.15	2.40	0.83	0.41	128.42		2.08
10 000 to 12 000	0.20	0.27				0.17	0.18	0.25	9.02		
12 000 to 14 000		0.15							0.85		
14 000 to 16 000									0.33		
16 000 to 18 000											
18 000 to 20 000											
20 000 to 22 000											
22 000 to 24 000											

TABLE V.- Continued

(e) Commercial survey operations

Altitude, ft	Flight hr per airplane -										
	19	19[1]	20	20[1]	21	22	23	24	24[1]	24[2]	24[3]
	Piston				T-jet & Pstn	Piston					
0 to 2 000	1.42	1.65	24.90	26.52	31.31	5.33	0.10	26.43	31.75	14.35	17.67
2 000 to 4 000	5.07	6.48	75.35	91.52	63.95	19.03	11.92	34.98	38.77	47.00	28.10
4 000 to 6 000	9.92	5.93	97.05	94.22	87.87	4.32	36.05	13.05	15.13	5.70	15.42
6 000 to 8 000	7.25	7.70	56.57	55.70	80.80	0.13	64.95	2.85	5.87	0.35	4.85
8 000 to 10 000	0.05	1.83	20.88	34.77	35.57		51.75	0.57	0.65		0.42
10 000 to 12 000			10.33	19.43	4.17		35.57		0.13		0.68
12 000 to 14 000			0.03	5.68	1.13		20.77				0.17
14 000 to 16 000					0.22		1.13				

TABLE V.- Continued

(e) Concluded

Altitude, ft	Flight hr per airplane -									
	24[4]	24[5]	25	4[1]	26	6A	27	9B	17[1]	28
	Piston									
0 to 2 000	32.28	45.15	4.42	4.68	455.70	20.72	31.62	12.28	1185.68	617.55
2 000 to 4 000	46.28	38.90	13.82	9.18	215.98	49.53	56.62	38.03	72.33	248.22
4 000 to 6 000	17.80	1.43	41.57	12.52	91.63	231.17	66.48	51.20		22.07
6 000 to 8 000	3.38		72.42	20.58	105.27	153.78	72.23	601.32		0.57
8 000 to 10 000	0.93		93.32	24.52	29.10	54.03	21.75	35.82		
10 000 to 12 000			17.95	7.05	3.17	24.60	4.07	1.35		
12 000 to 14 000			1.48	0.80		7.32				
14 000 to 16 000			1.43			2.20				
16 000 to 18 000						1.68				
18 000 to 20 000										
20 000 to 22 000										
22 000 to 24 000										

TABLE V.- Continued

(f) Aerial application operations

Altitude, ft	Flight hr per airplane -												
	29	29[1]	30	30[1]	30[2]	30A	31	32	32[1]	32[2]	33	33[1]	33A
	Turboprop		Piston					Turboprop			Piston		
0 to 2 000	335.32	297.33	119.68	2.93	140.40	777.78	7.50	99.63	52.12	189.50	348.77	123.57	44.55
2 000 to 4 000	2.45	0.35	7.27	43.75		3.73	161.43	0.30	0.85	3.52	2.08		
4 000 to 6 000	0.93					0.15	4.62		0.50	2.58			
6 000 to 8 000	0.18								0.07	2.07			
8 000 to 10 000									0.15	2.32			
10 000 to 12 000									0.33	1.18			
12 000 to 14 000										0.42			
14 000 to 16 000										0.07			
16 000 to 18 000													

TABLE V.- Continued

(f) Concluded

Altitude, ft	Flight hr per airplane -												
	33A[1]	33A[2]	34	34[1]	34[2]	34[3]	35	35[1]	35[2]	36	36A	37	37[1]
	Piston												
0 to 2 000	22.70	12.78	13.13	201.65	169.25	320.13	40.92	354.75	0.00	207.65	71.53	174.60	0.00
2 000 to 4 000			15.08	1.00	12.43	1.75	277.20	31.65	118.30			0.42	344.38
4 000 to 6 000			1.82		3.23		33.62	4.63	16.85				
6 000 to 8 000			0.83		0.85		4.50	0.80	1.55				
8 000 to 10 000			0.17		1.12		0.43		0.48				
10 000 to 12 000									0.15				
12 000 to 14 000													
14 000 to 16 000													
16 000 to 18 000													

TABLE V.- Concluded

Altitude, ft	(g) Aerobatic	(h) Commuter		(i) Float
	Flight hr per airplane -	Flight hr per airplane -		Flight hr per airplane -
	38	39	40	41
	Piston	Turboprop		Piston
0 to 2 000	104.63	965.60	539.80	370.45
2 000 to 4 000	56.55	866.72	799.32	411.60
4 000 to 6 000	9.00	174.25	618.87	66.57
6 000 to 8 000	0.08	42.23	526.33	25.27
8 000 to 10 000		6.37	175.45	8.65
10 000 to 12 000		0.55	23.20	1.13
12 000 to 14 000			1.15	0.82
14 000 to 16 000			0.37	0.12
16 000 to 18 000				

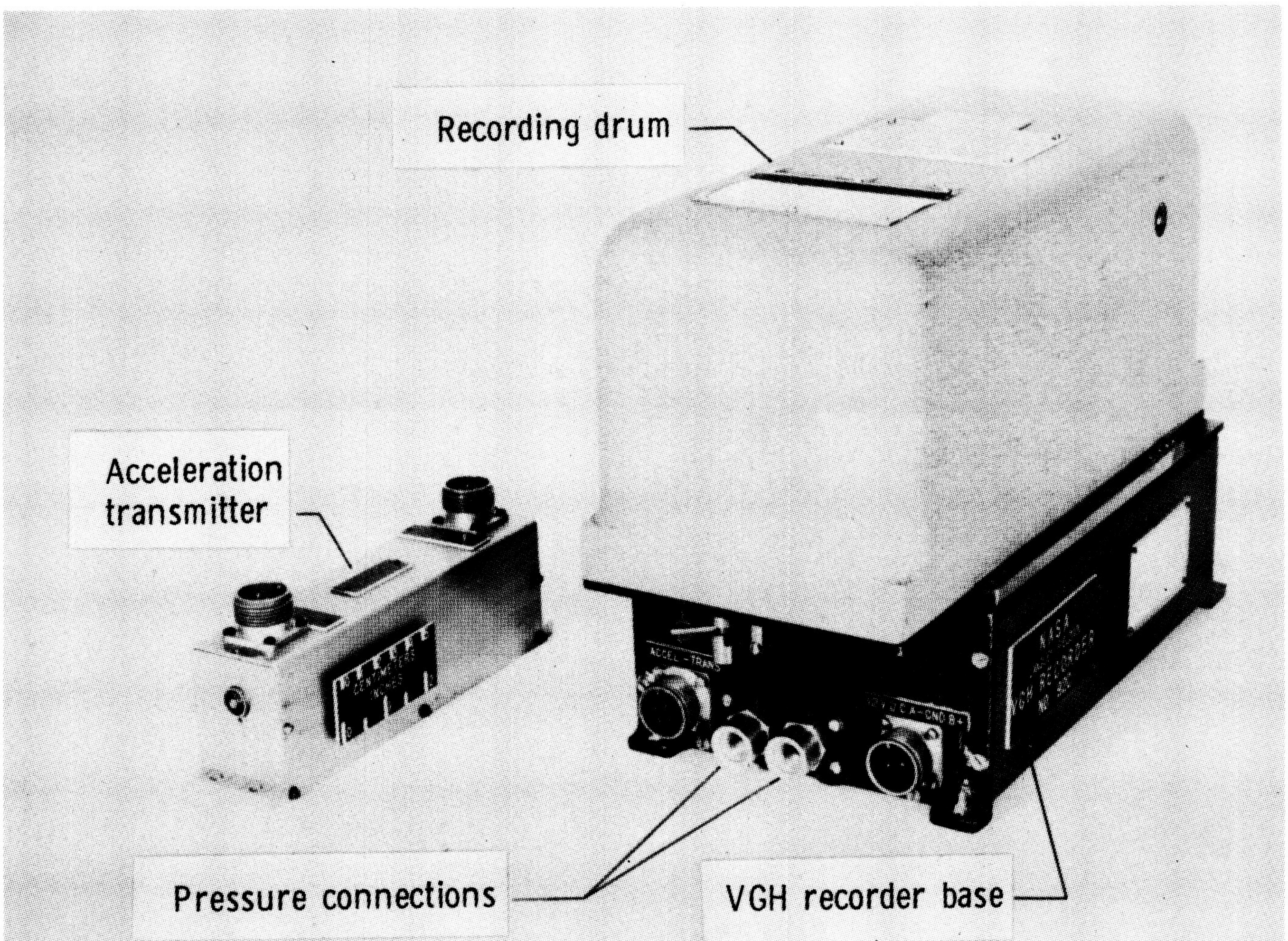

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Figure 1.- NASA VGH recorder.

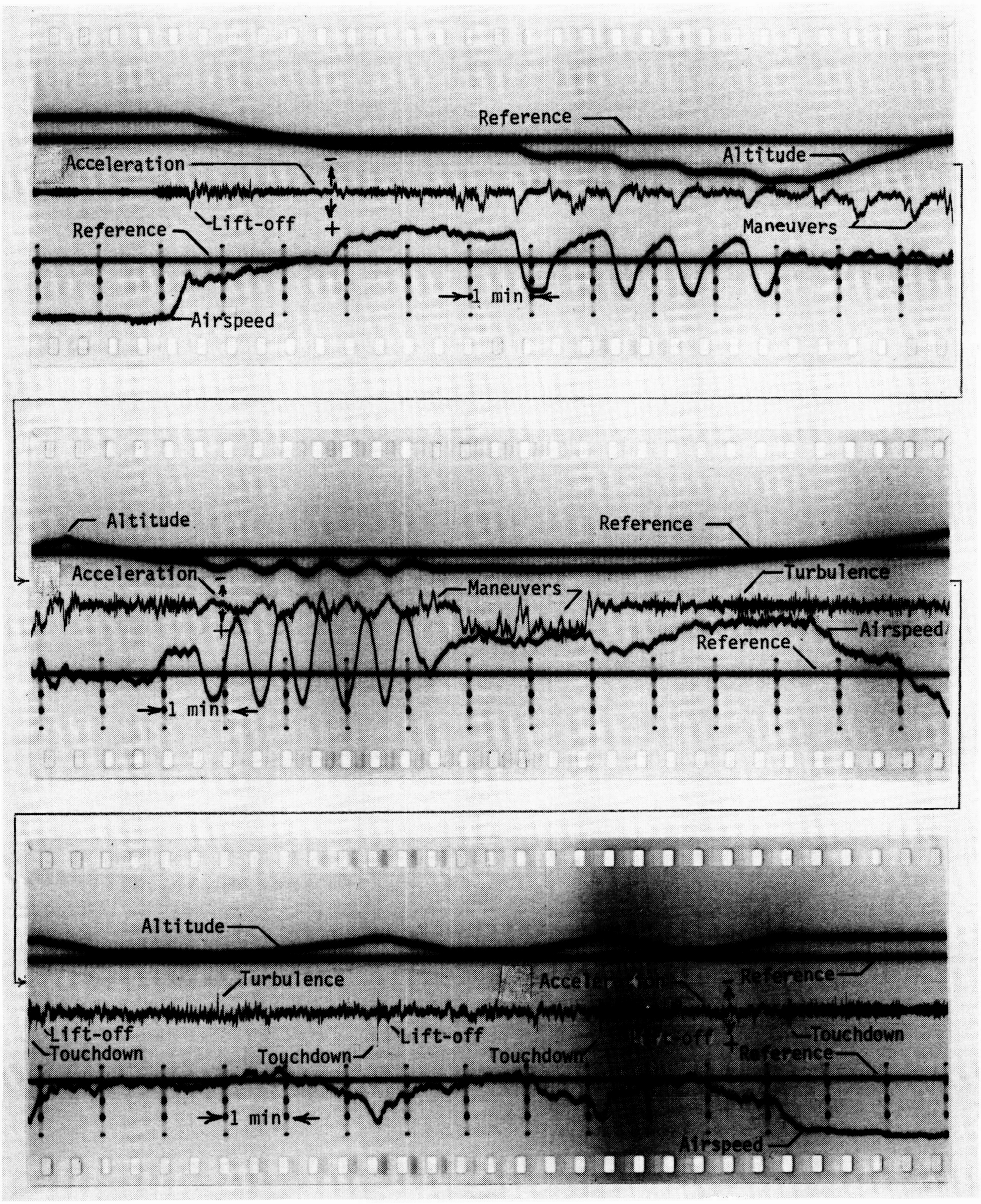


Figure 2.- Sample VGH record from flight performed in instructional operations.

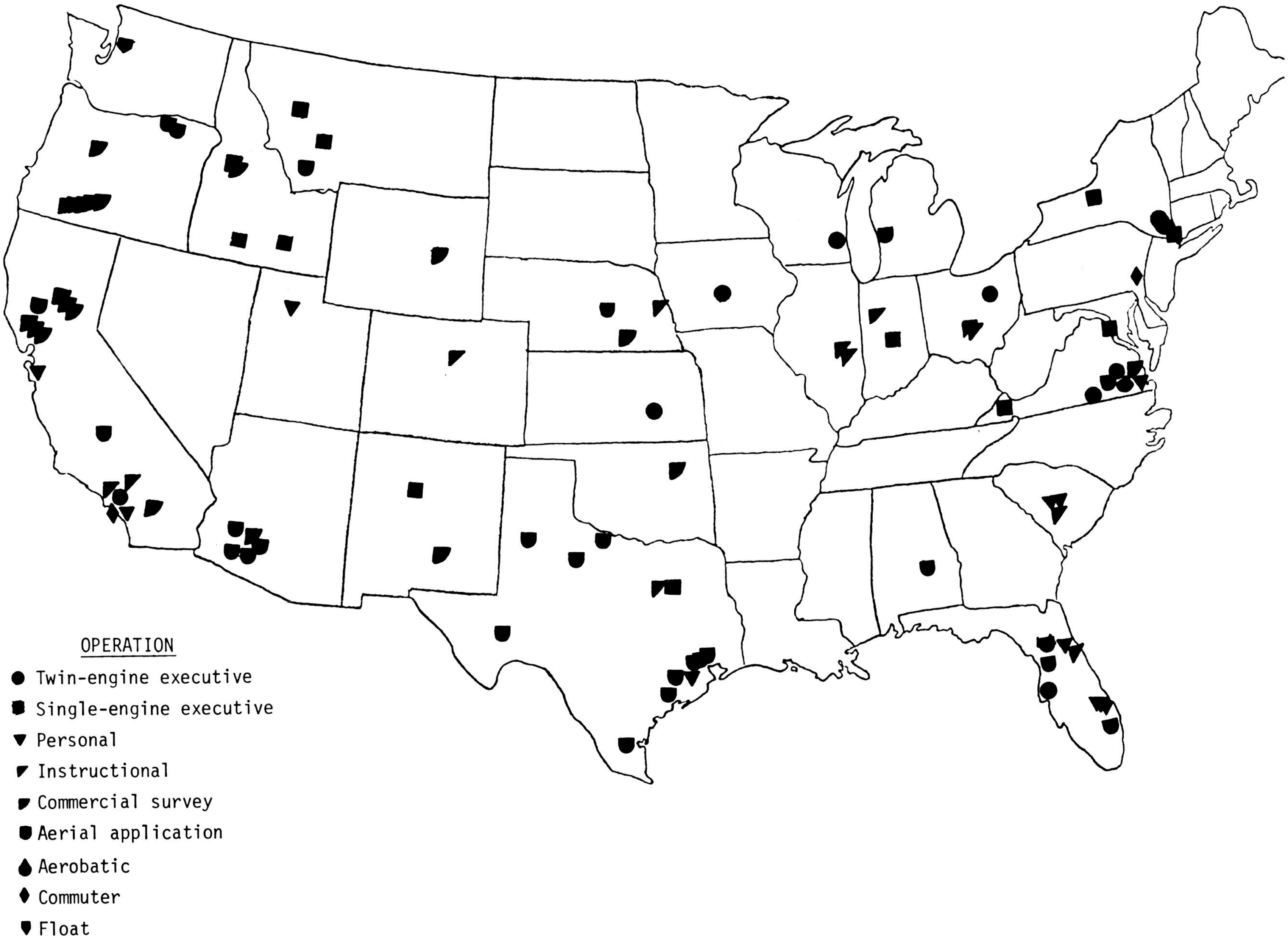
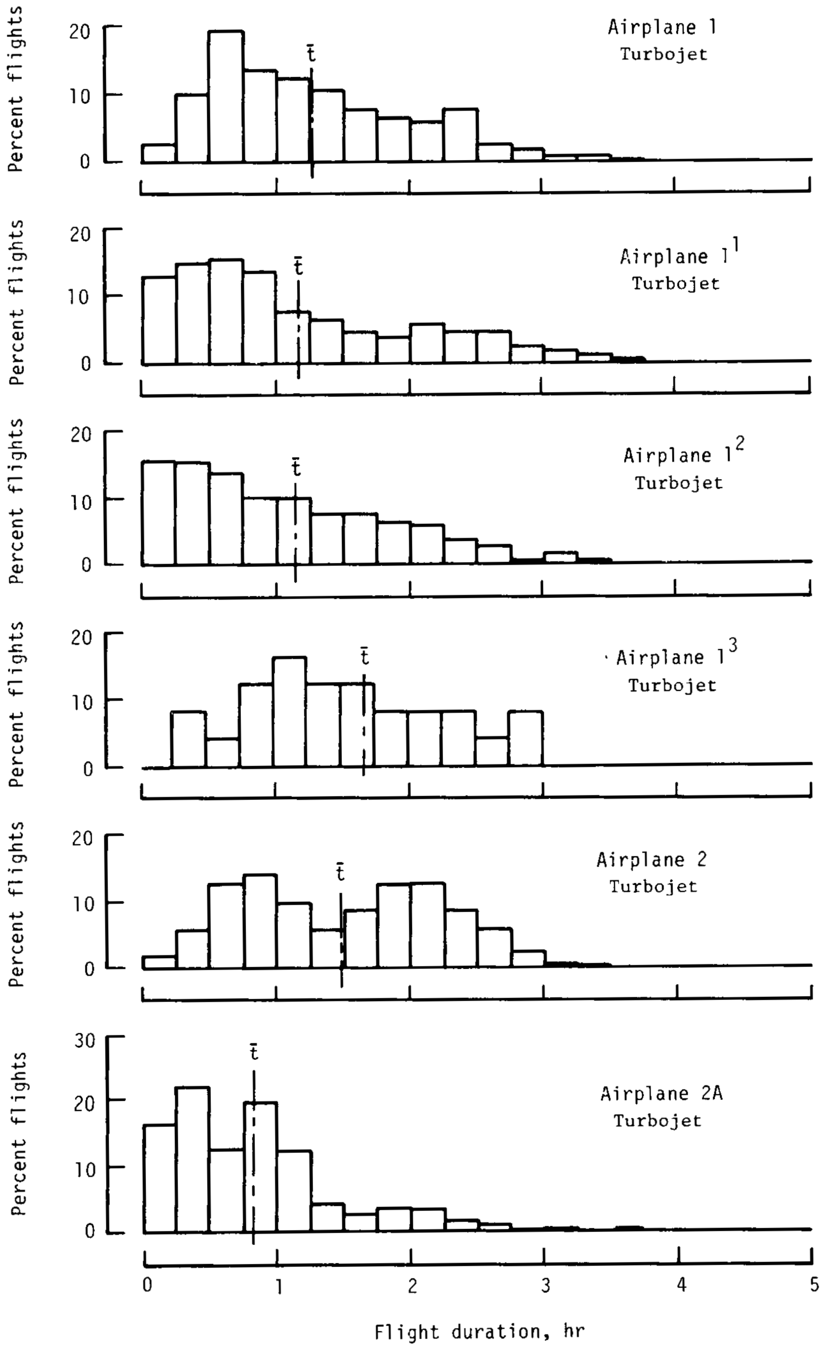
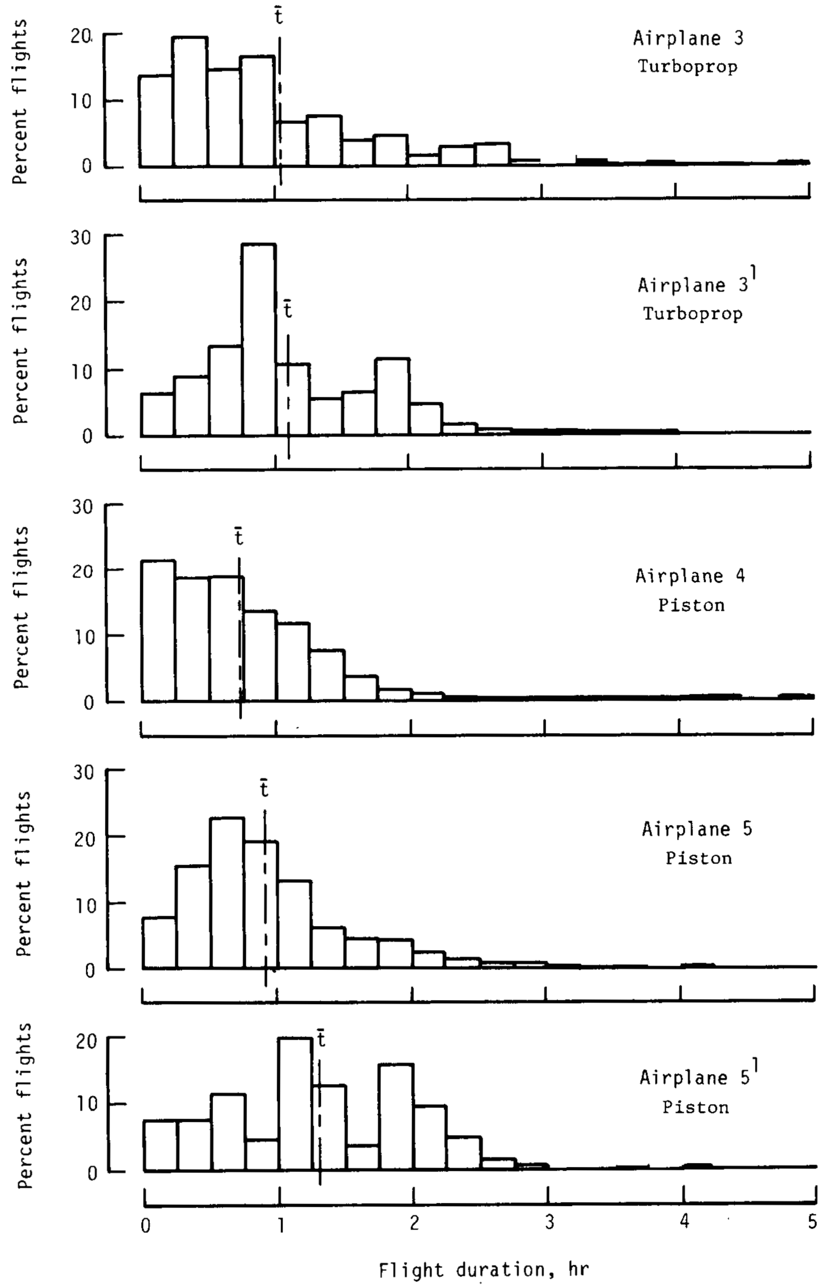


Figure 3.- Home bases of instrumented airplanes.



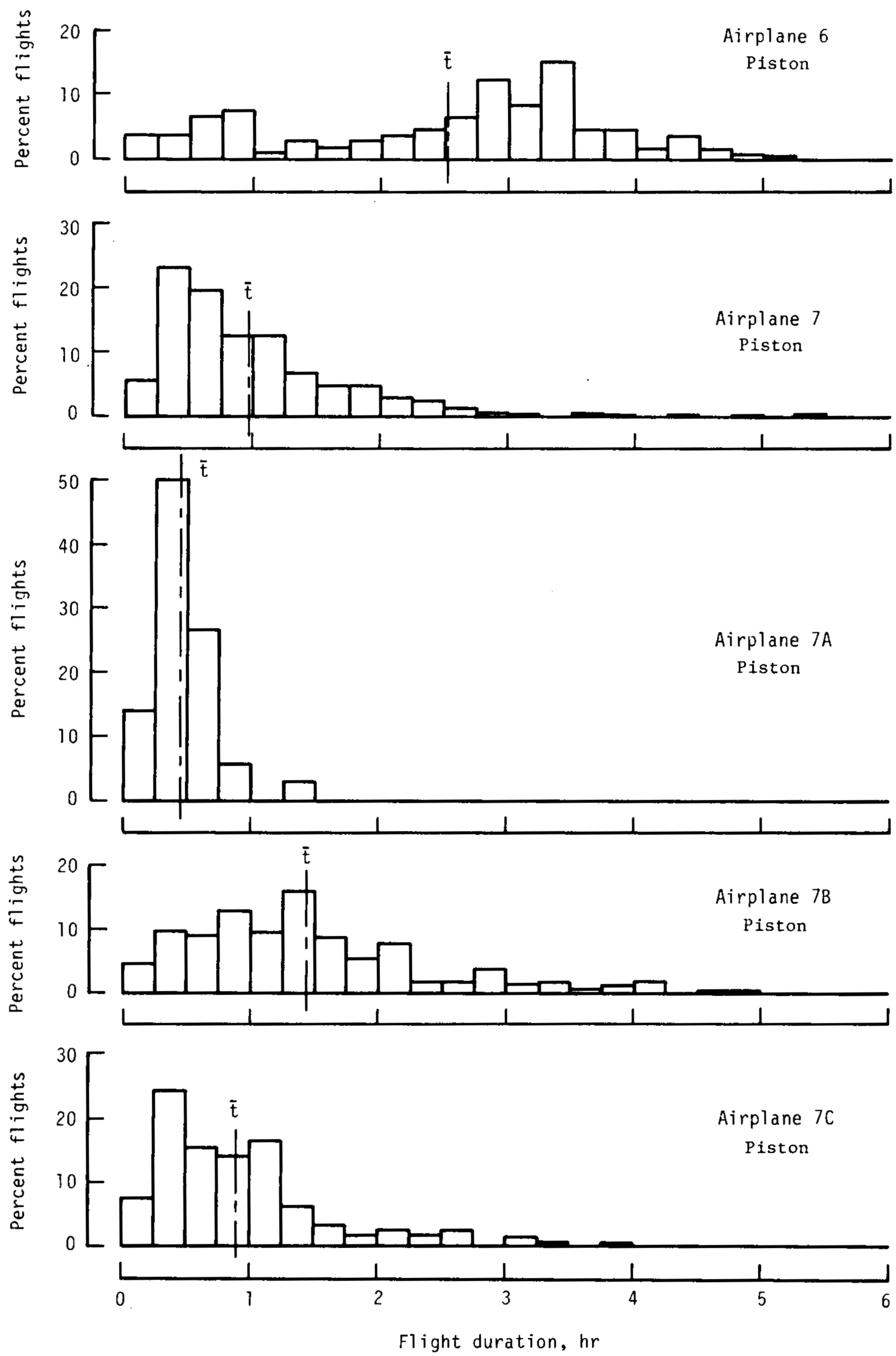
(a) Twin-engine executive operations.

Figure 4.- Variation of flight duration for individual airplanes flown in specified types of operations.



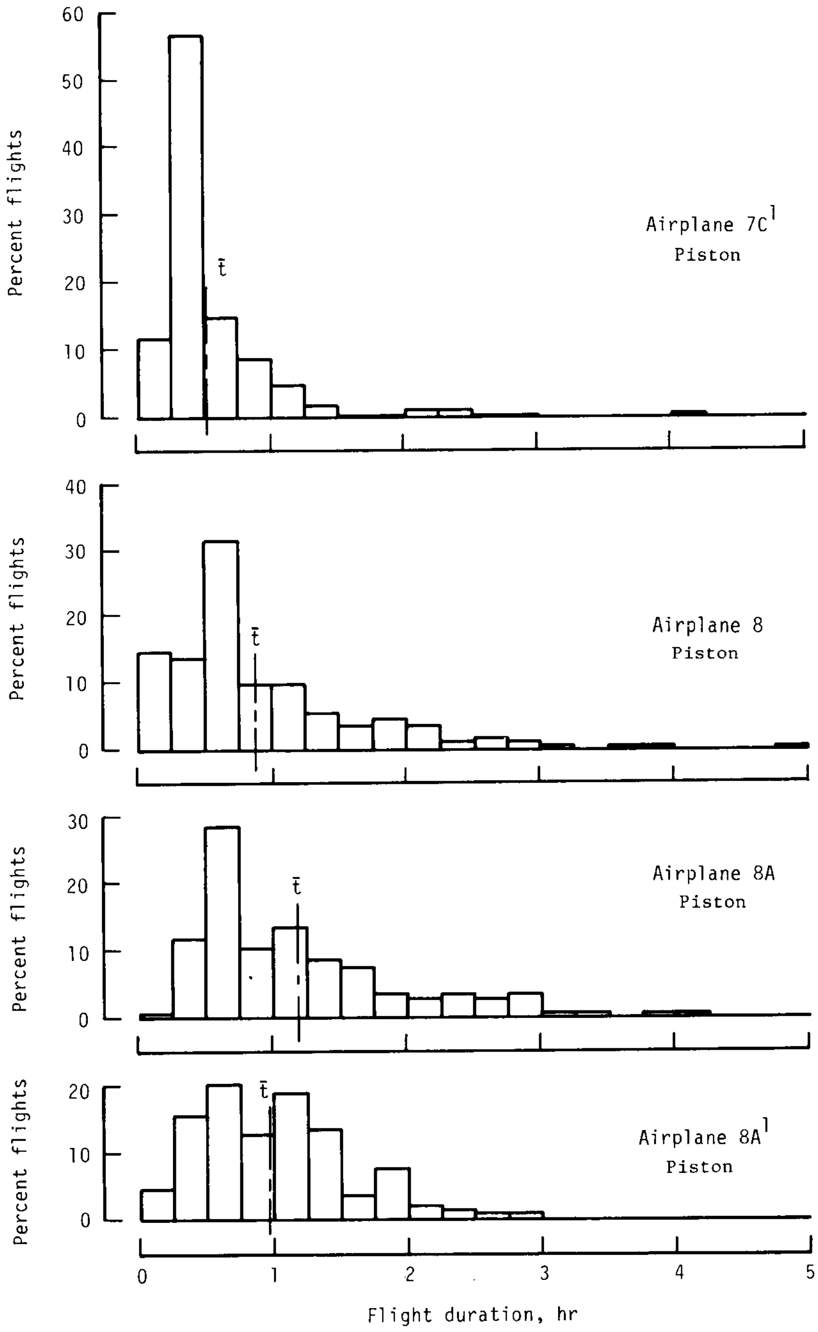
(a) Concluded.

Figure 4.- Continued.



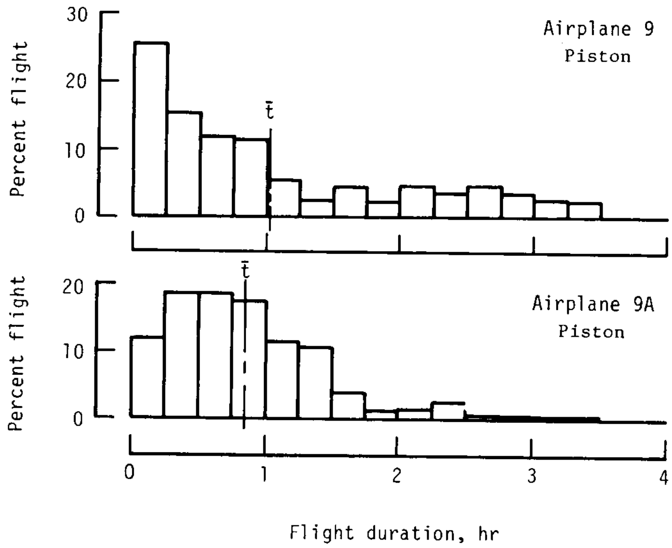
(b) Single-engine executive operations.

Figure 4.- Continued.



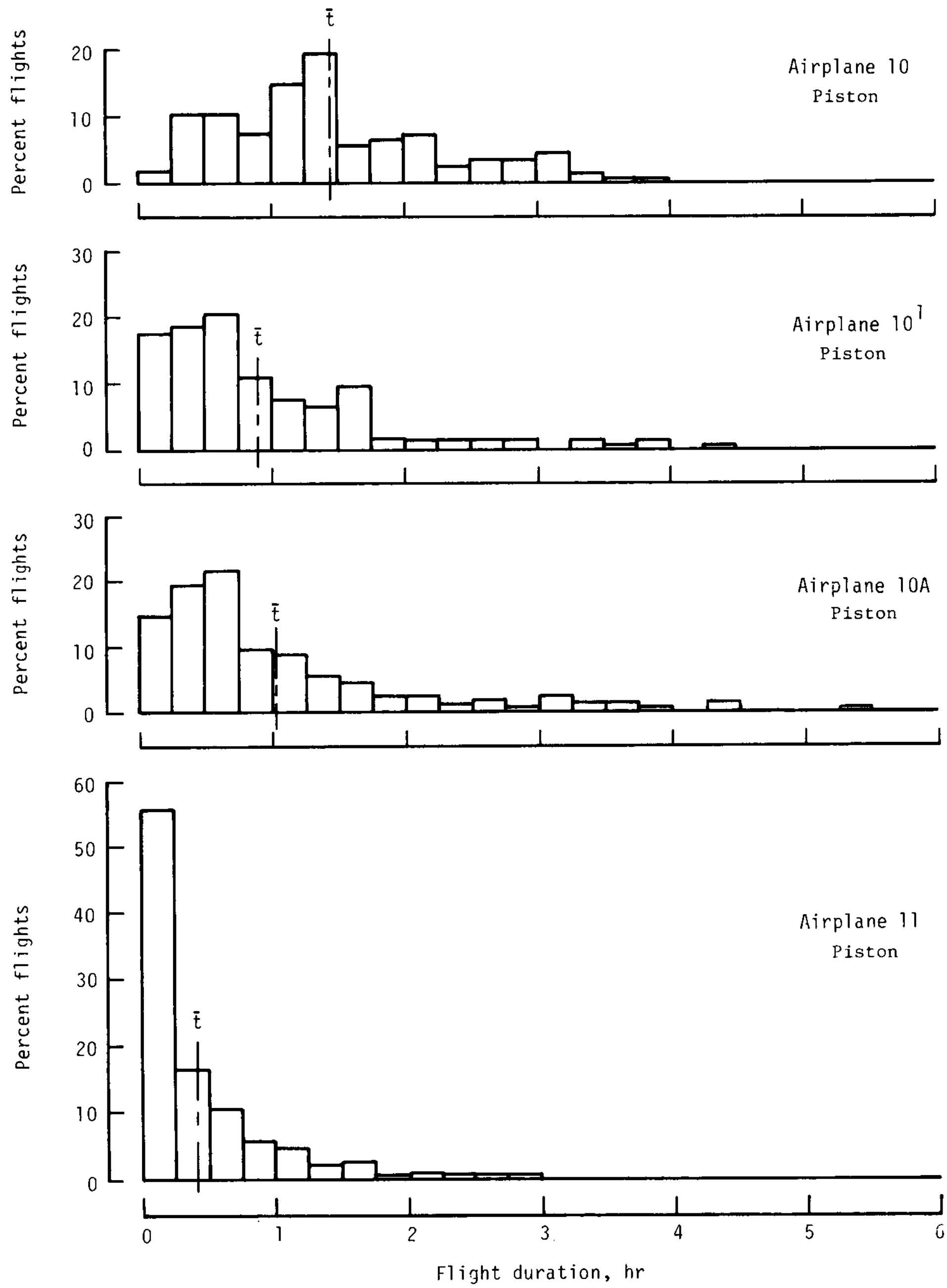
(b) Continued.

Figure 4.- Continued.



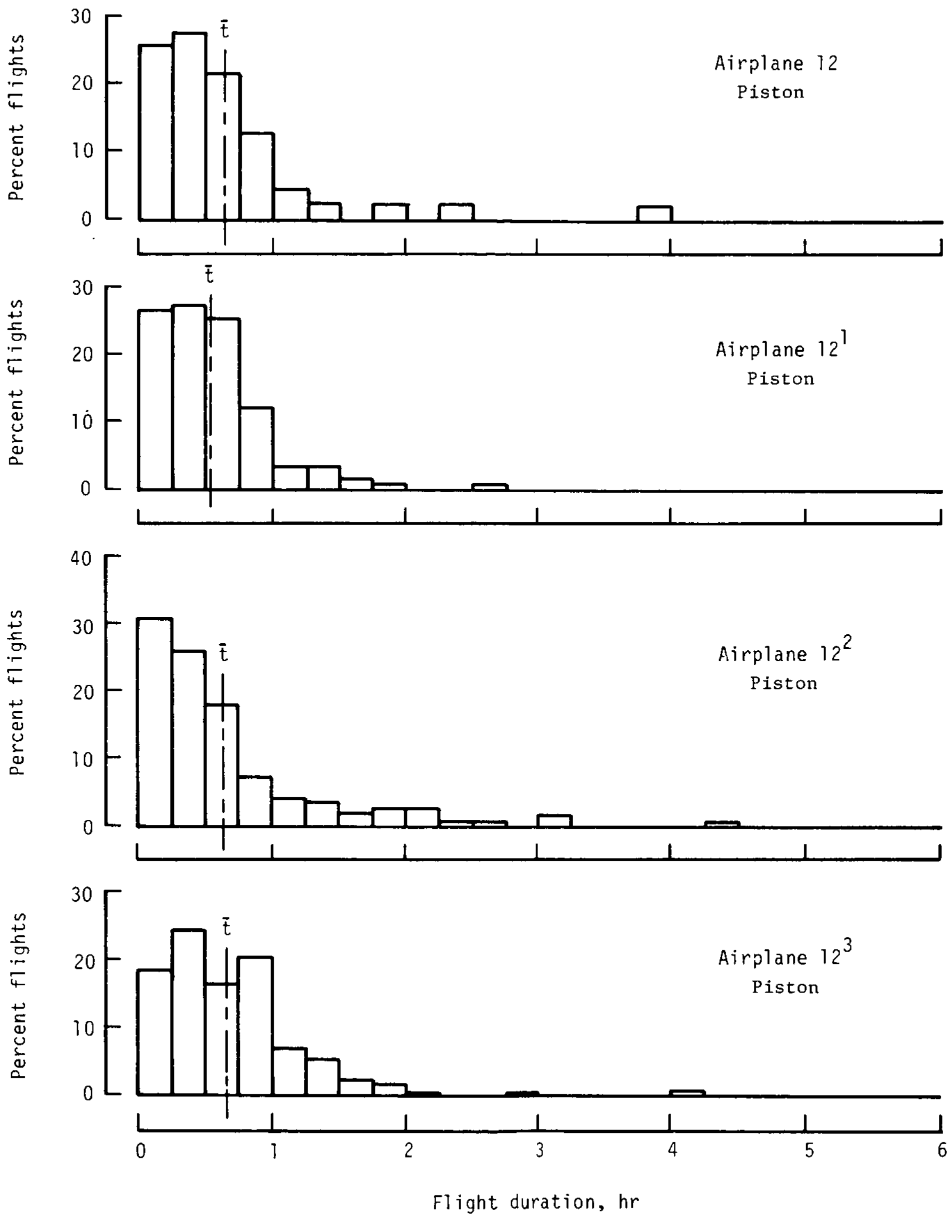
(b) Concluded.

Figure 4.- Continued.



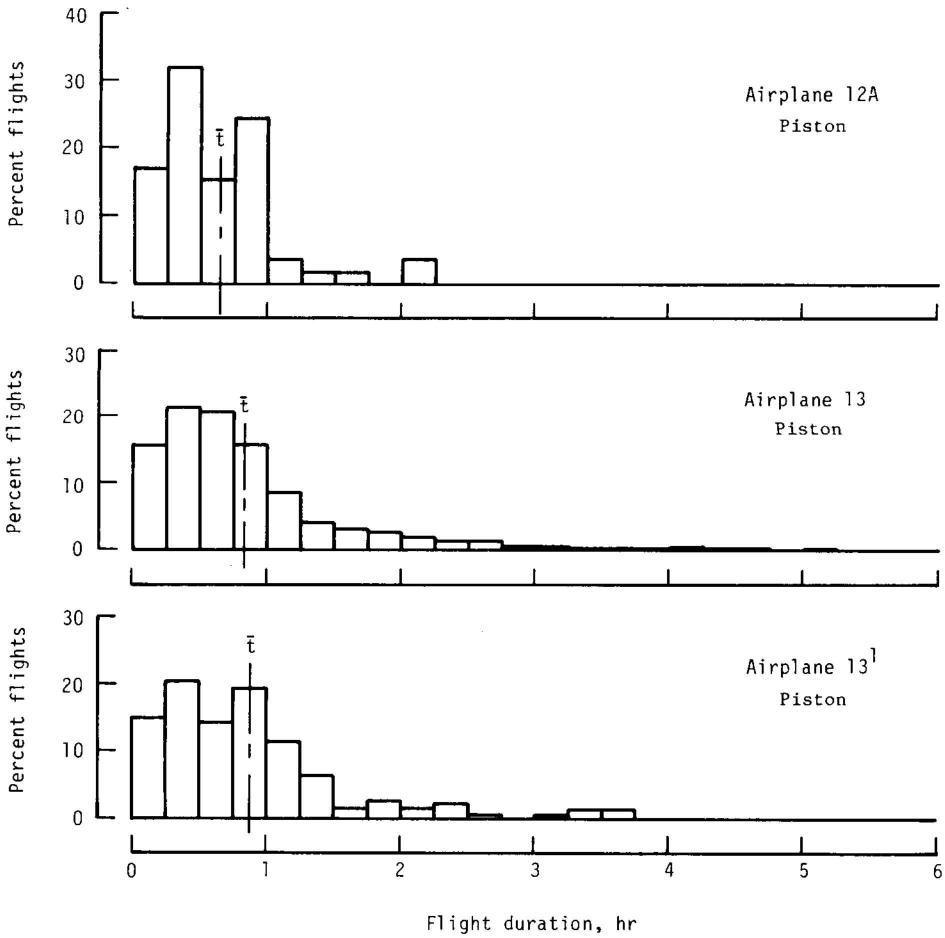
(c) Personal operations.

Figure 4.- Continued.



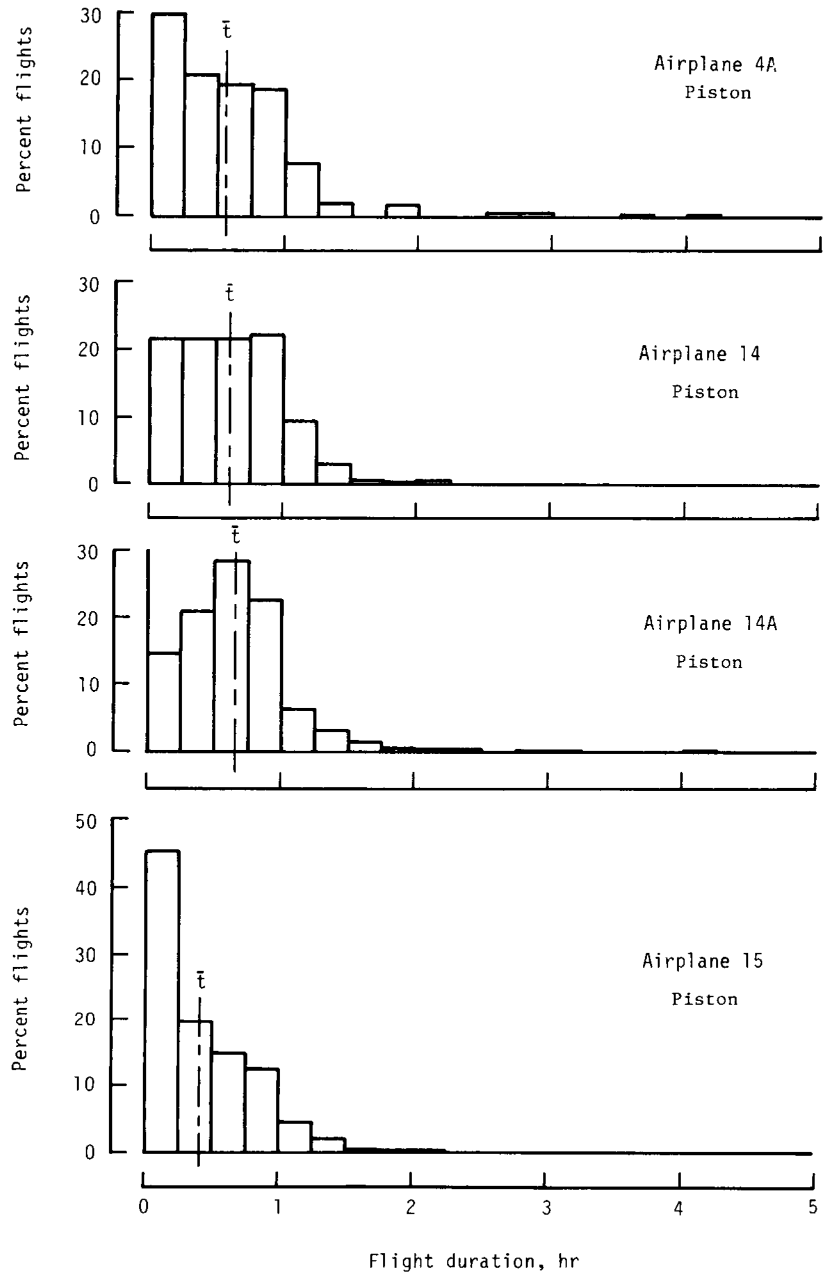
(c) Continued.

Figure 4.- Continued.



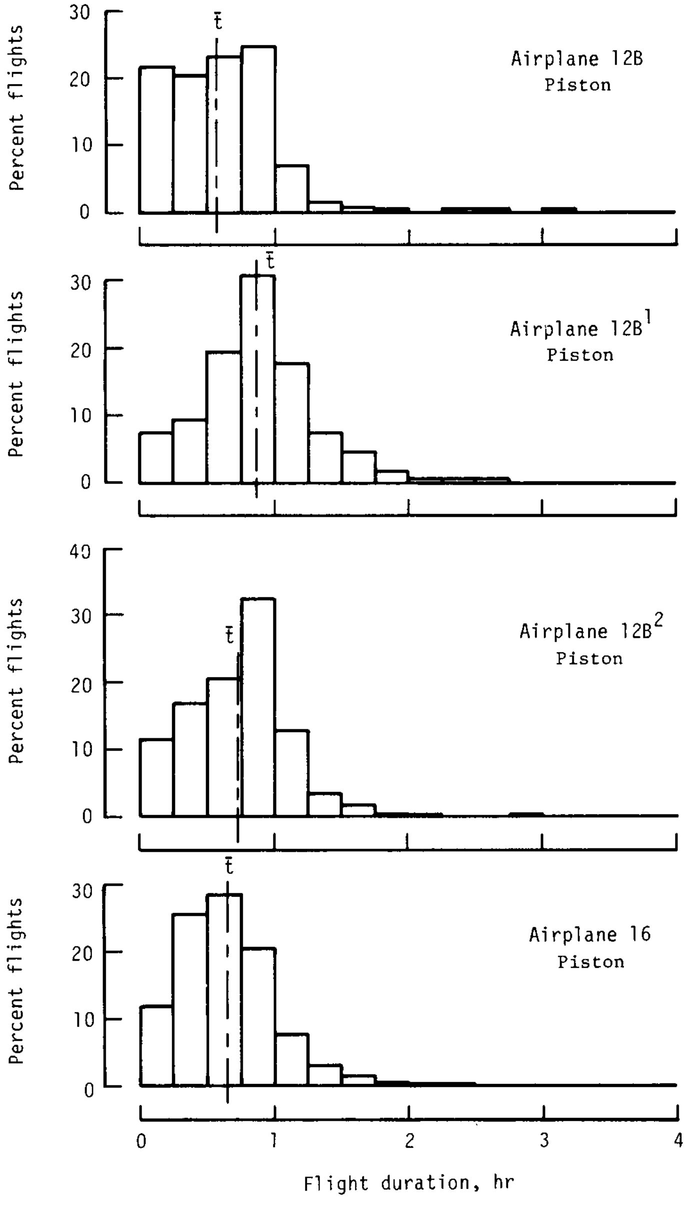
(c) Concluded.

Figure 4.- Continued.



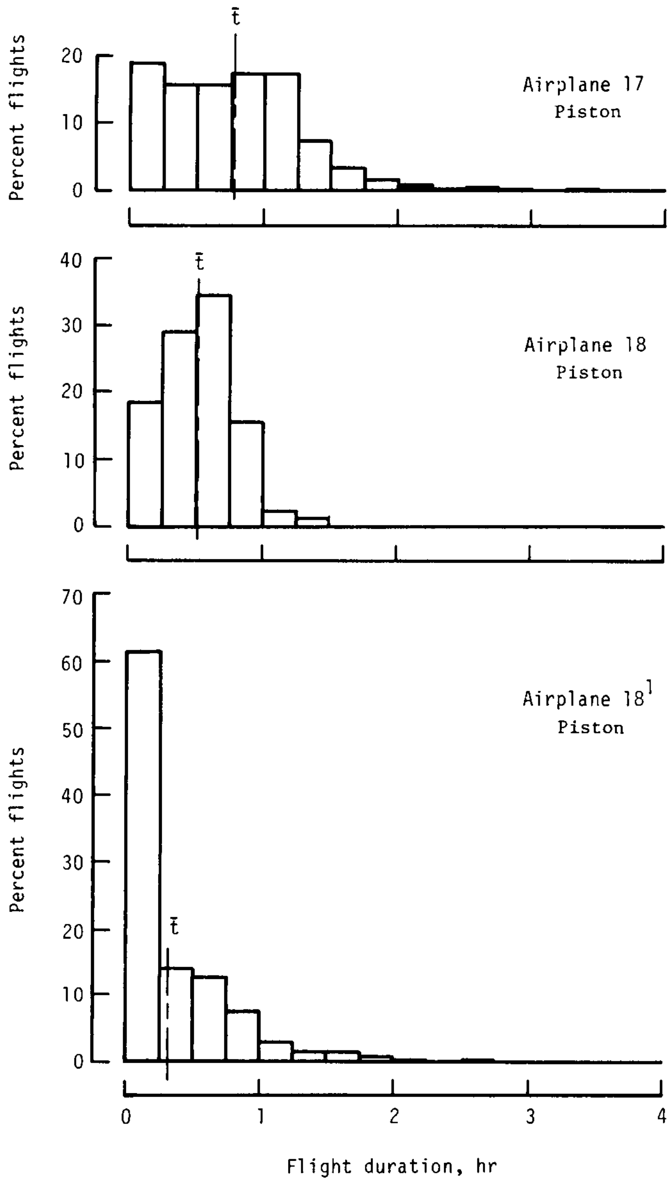
(d) Instructional operations.

Figure 4.- Continued.



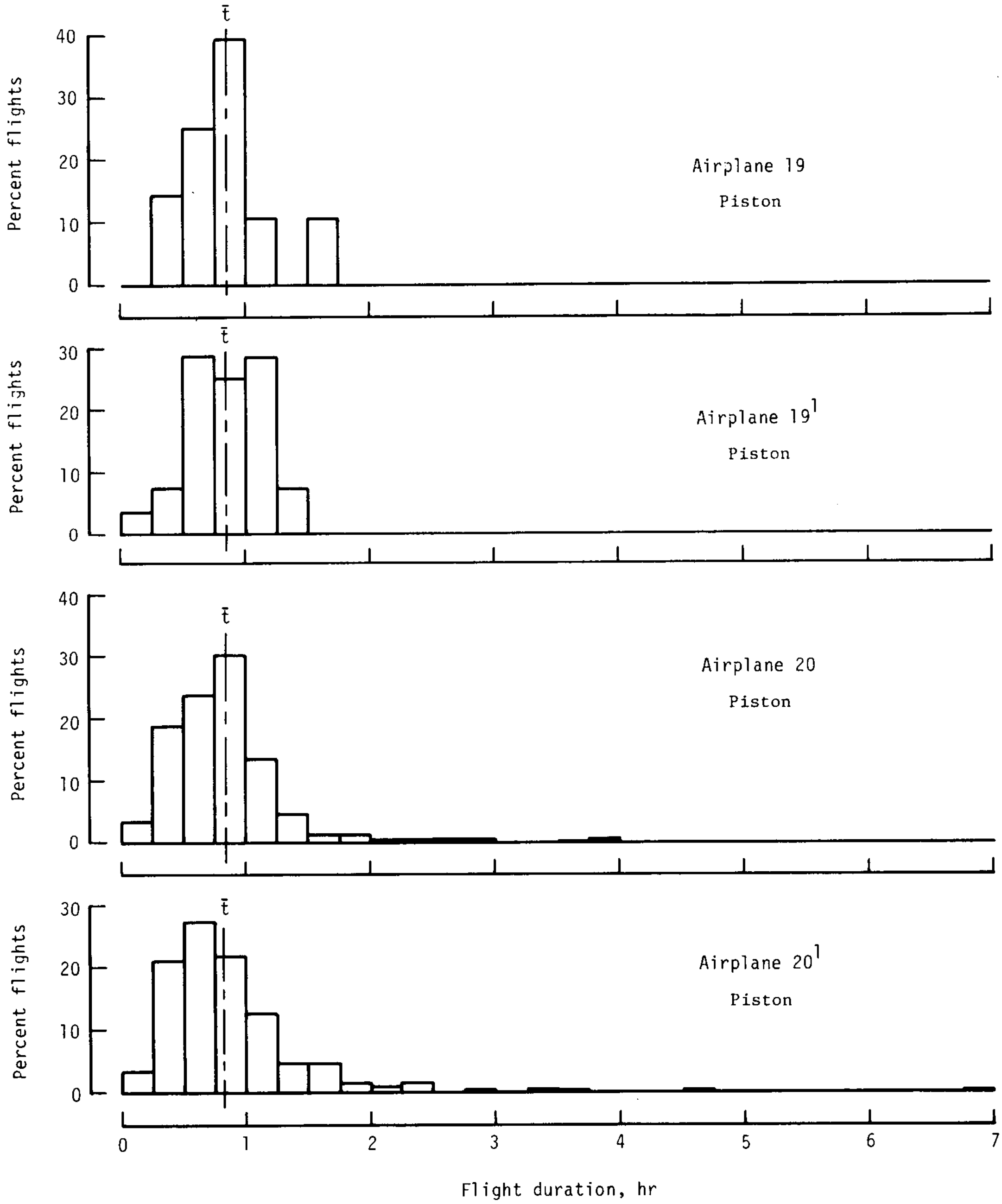
(d) Continued.

Figure 4.- Continued.



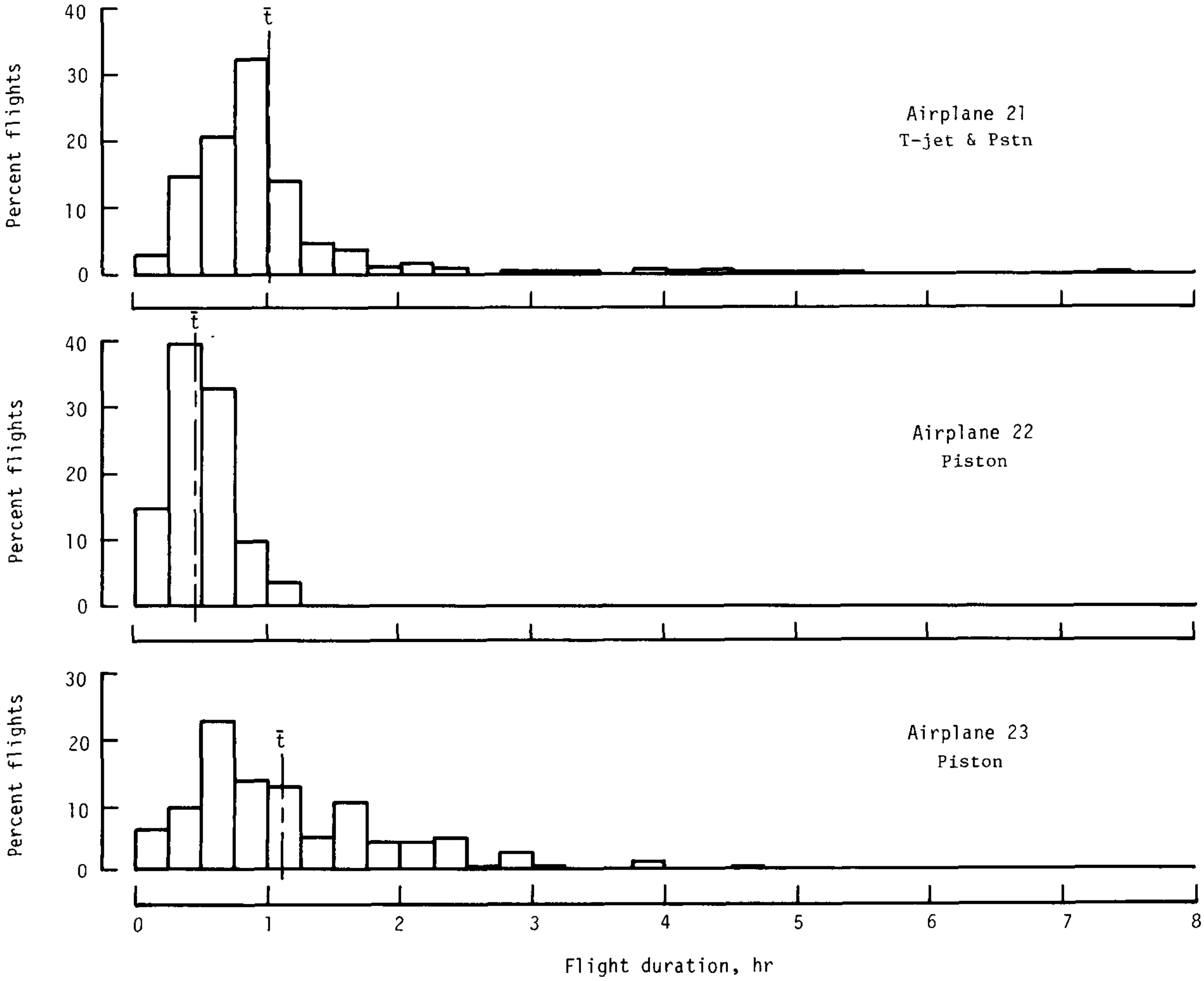
(d) Concluded.

Figure 4.- Continued.



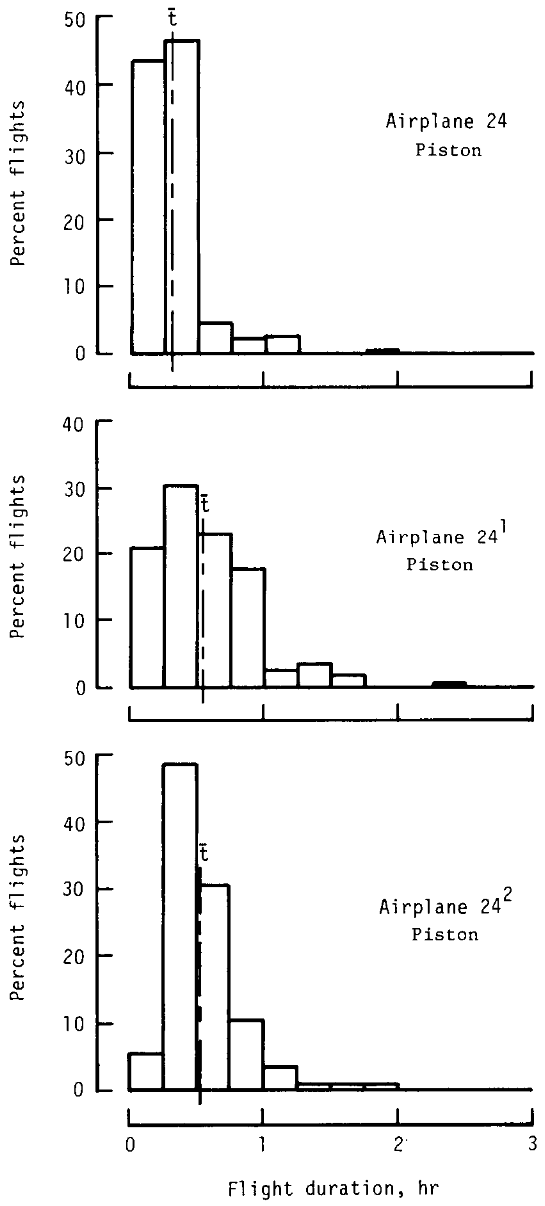
(e) Commercial survey operations.

Figure 4.- Continued.



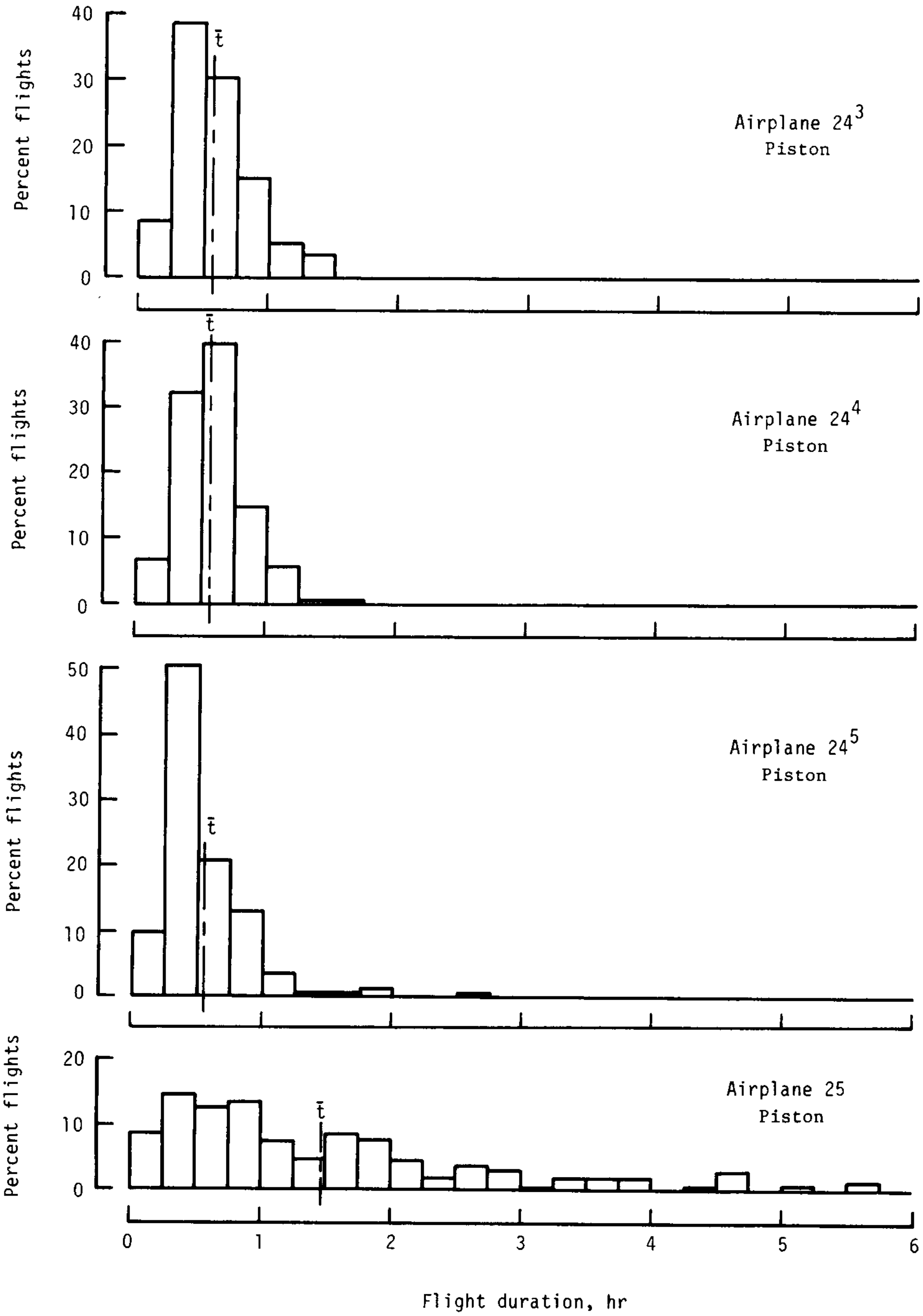
(e) Continued.

Figure 4.- Continued.



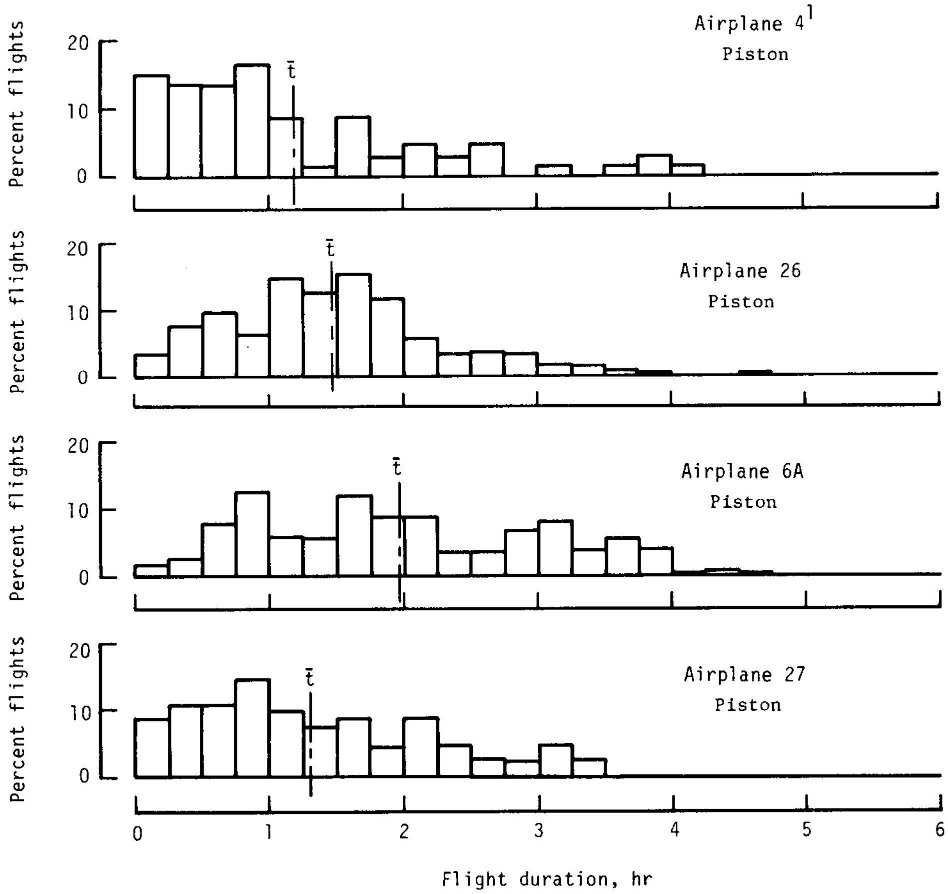
(e) Continued.

Figure 4.- Continued.



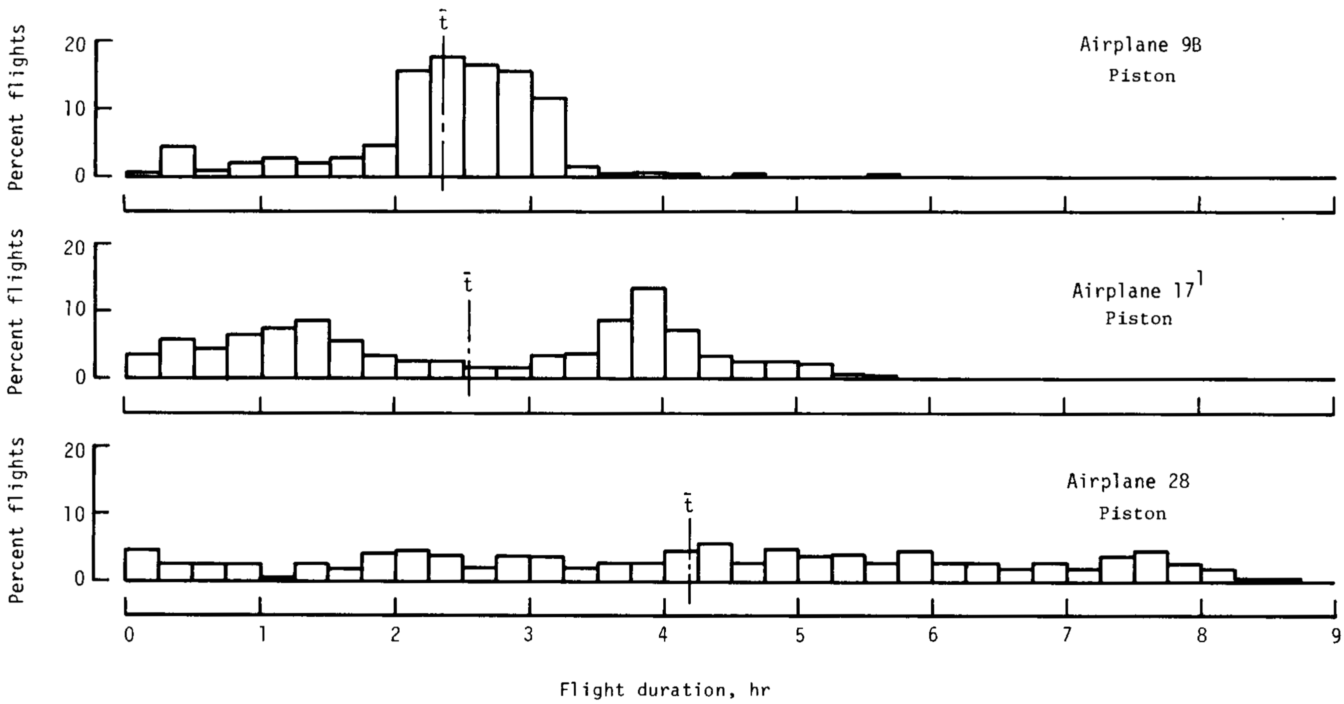
(e) Continued.

Figure 4.- Continued.



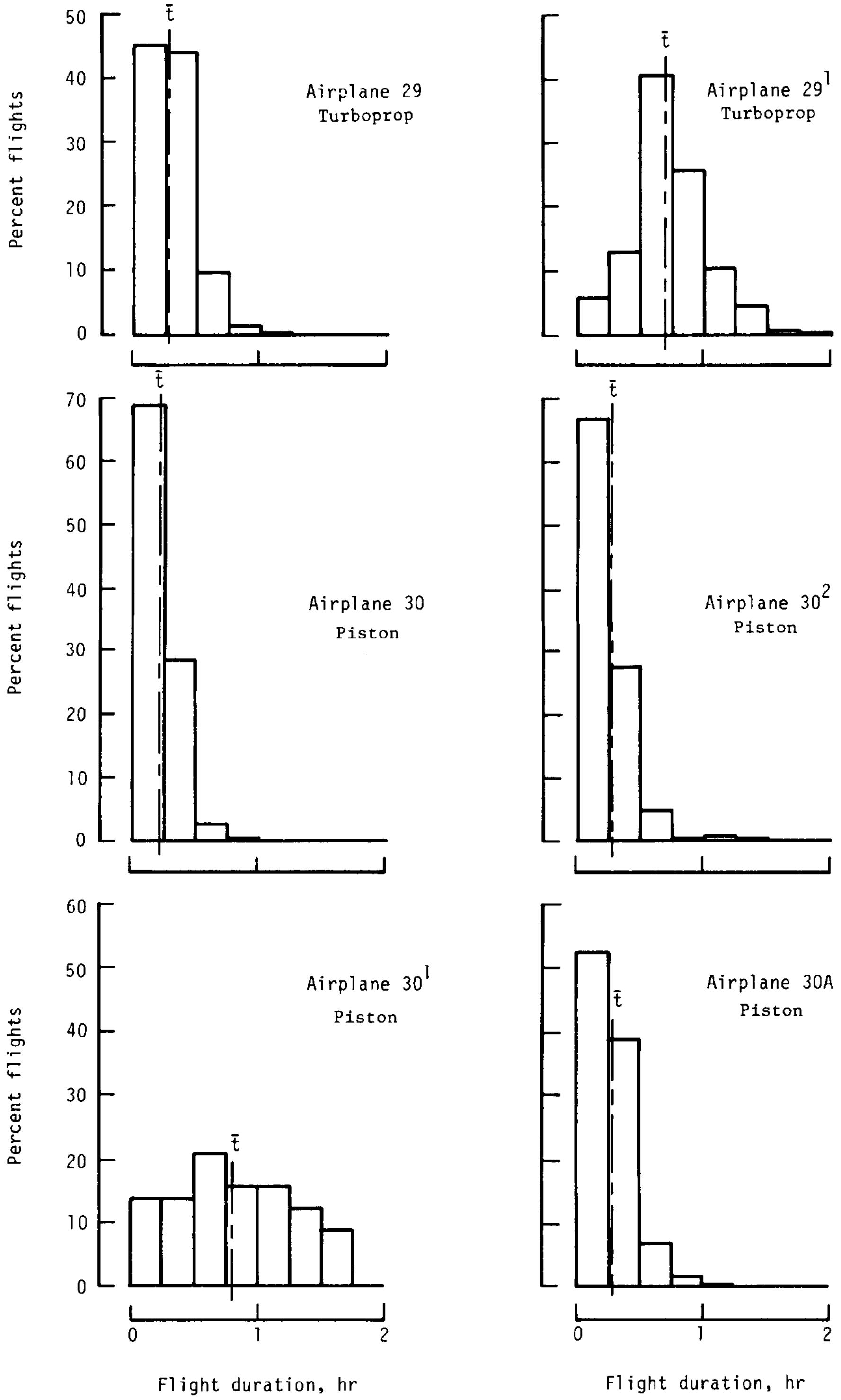
(e) Continued.

Figure 4.- Continued.



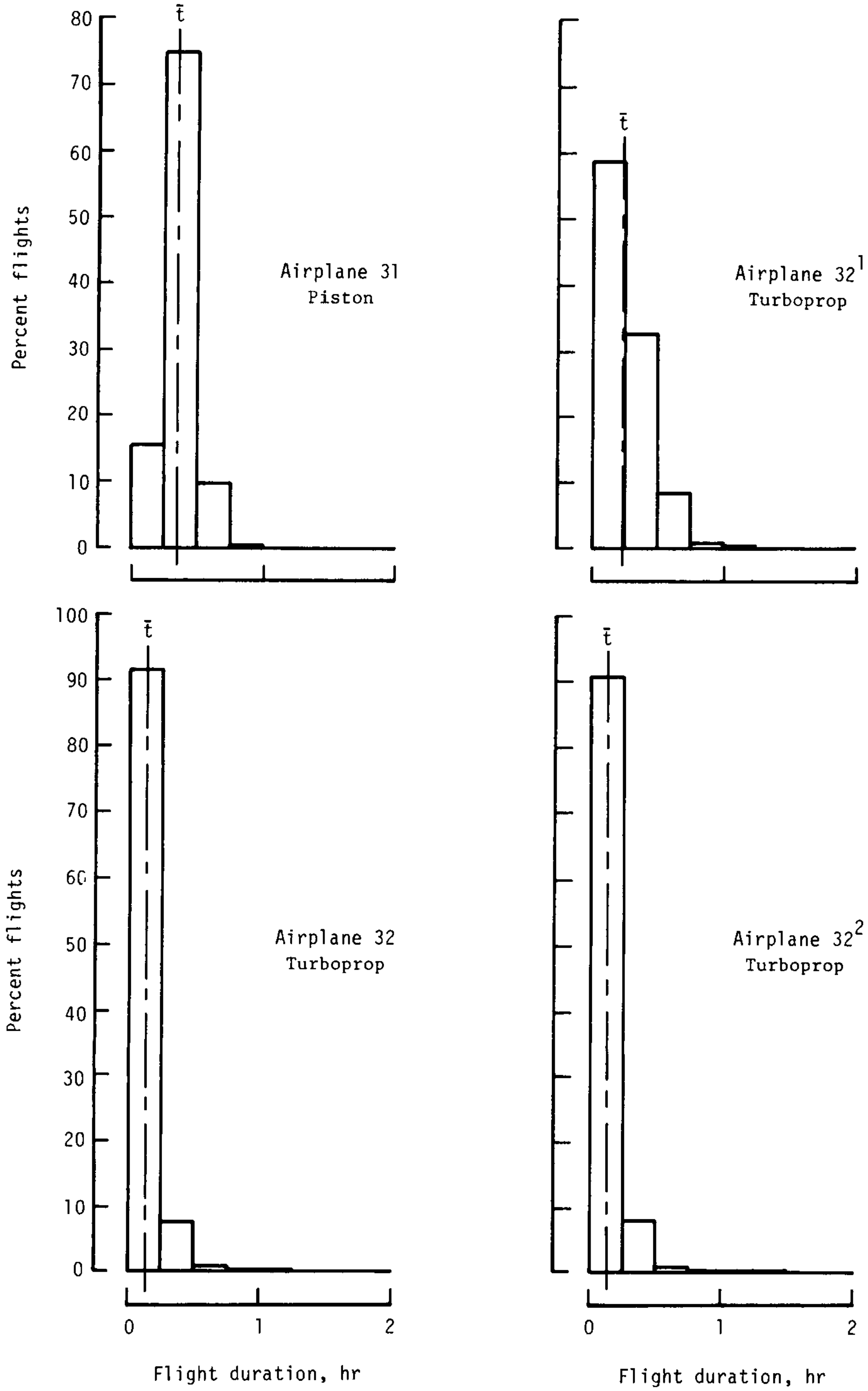
(e) Concluded.

Figure 4.- Continued.



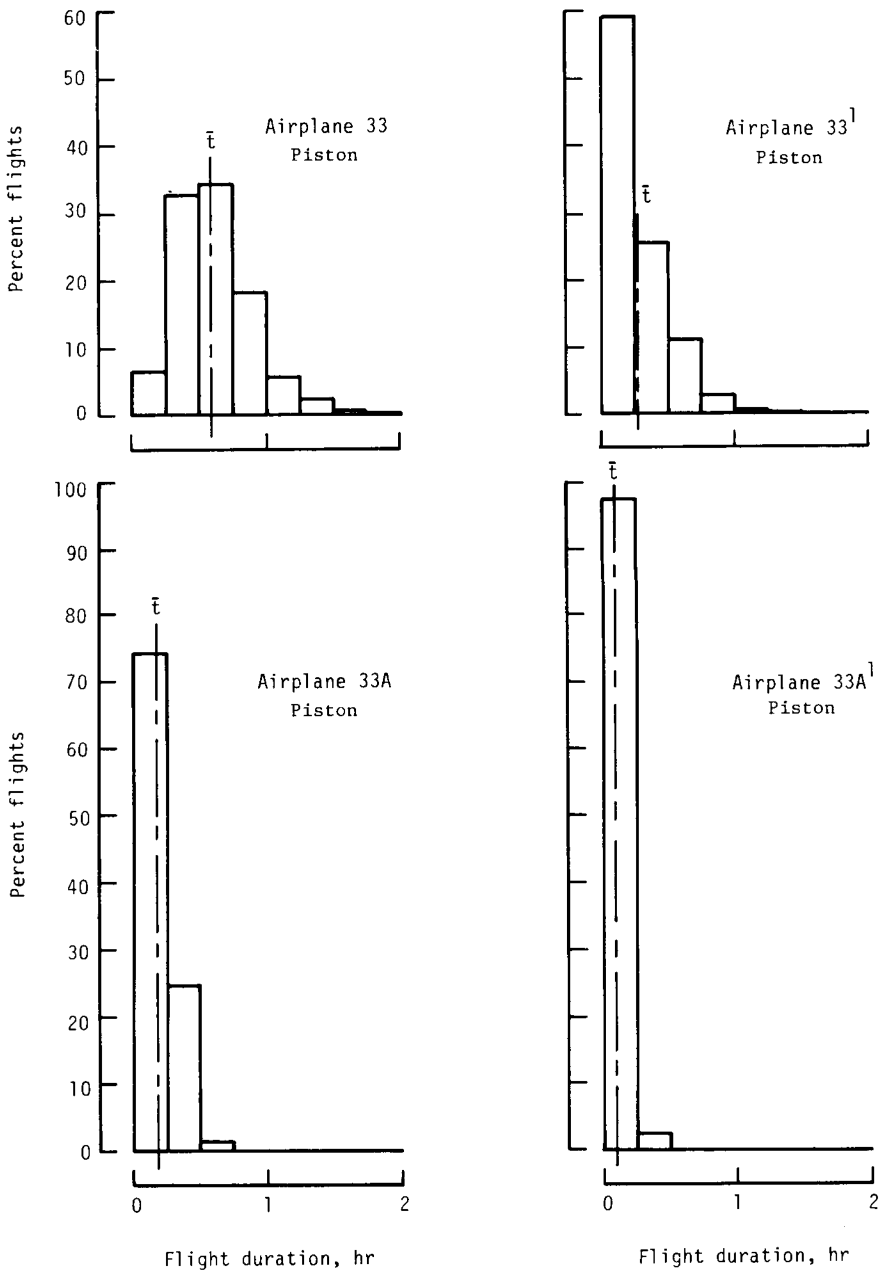
(f) Aerial application operations.

Figure 4.- Continued.



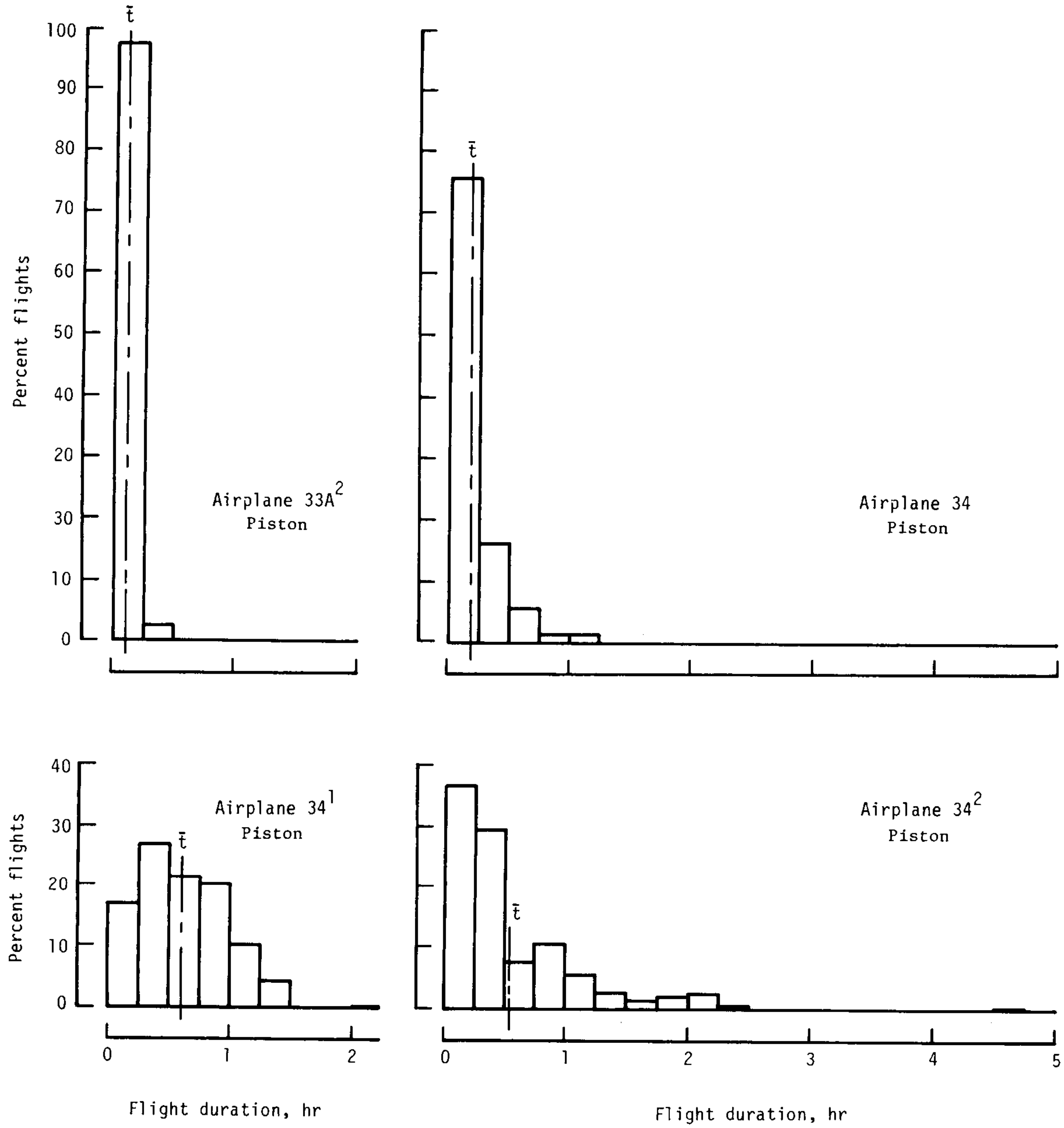
(f) Continued.

Figure 4.- Continued.



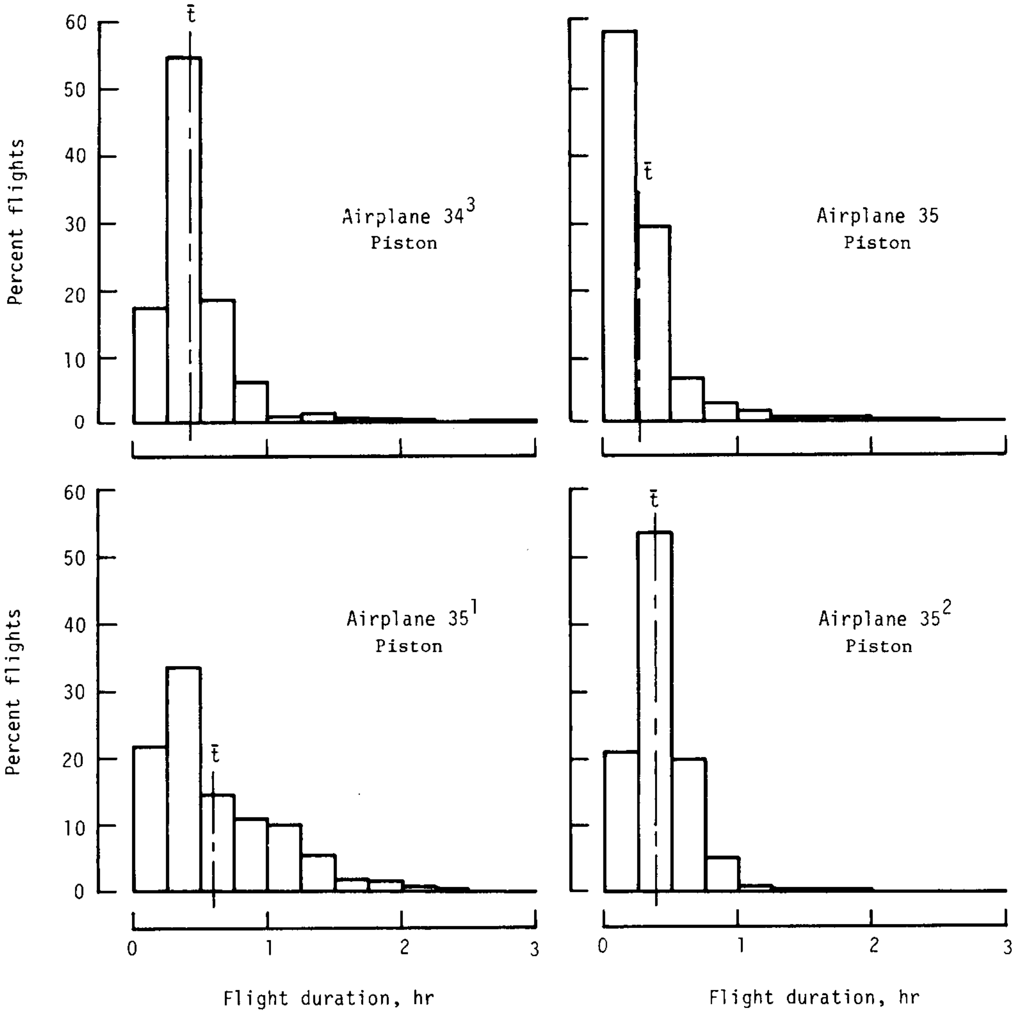
(f) Continued.

Figure 4.- Continued.



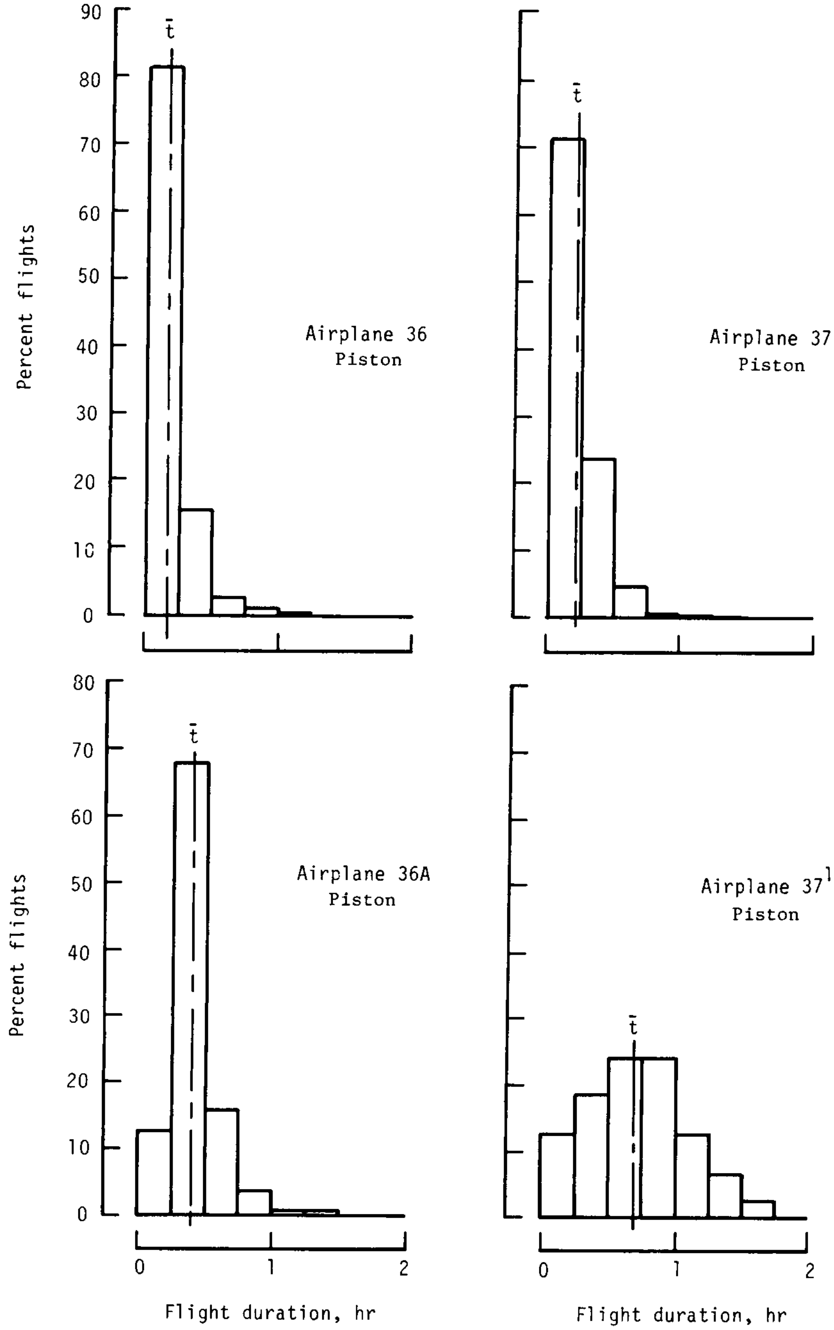
(f) Continued.

Figure 4.- Continued.



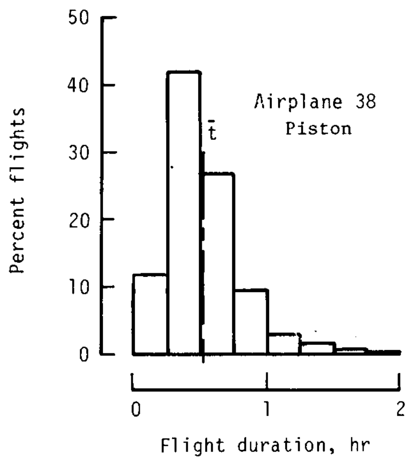
(f) Continued.

Figure 4.- Continued.

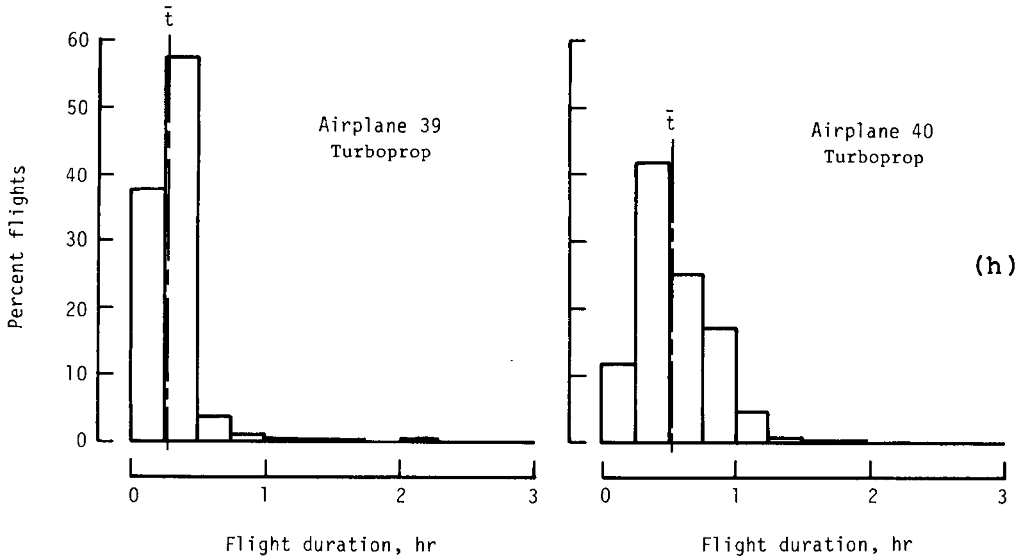


(f) Concluded.

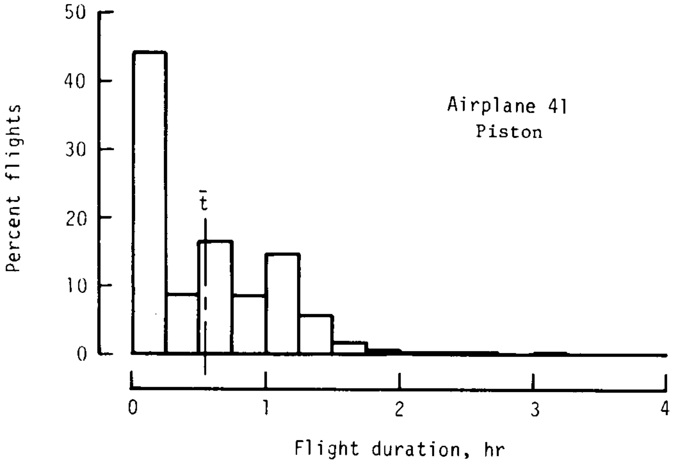
Figure 4.- Continued.



(g) Aerobatic operations.

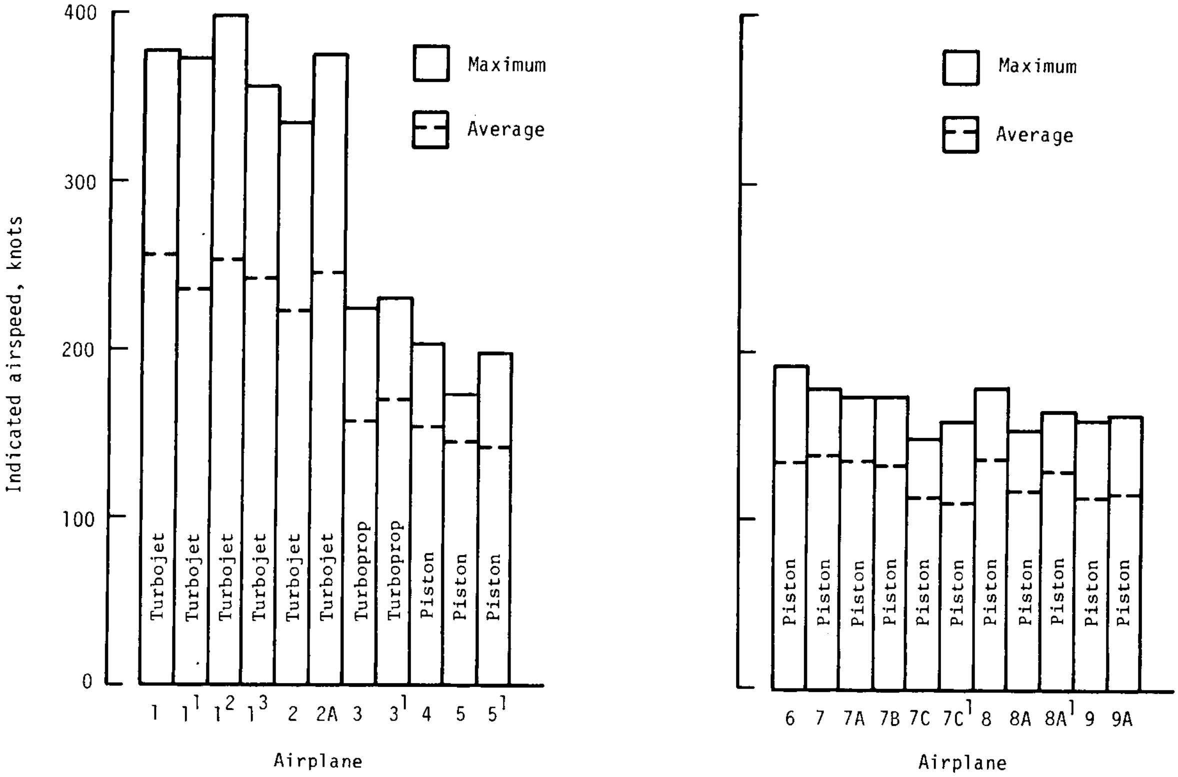


(h) Commuter operations.



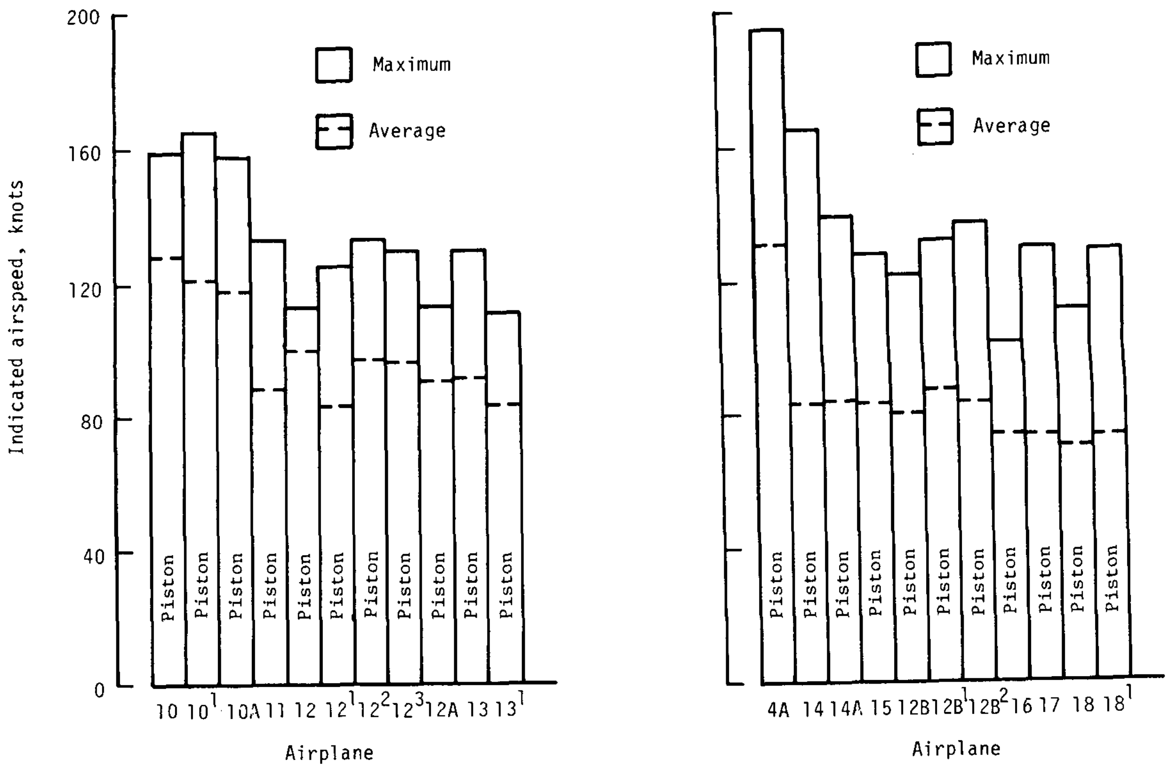
(i) Float operations.

Figure 4.- Concluded.



(a) Twin-engine executive operations. (b) Single-engine executive operations.

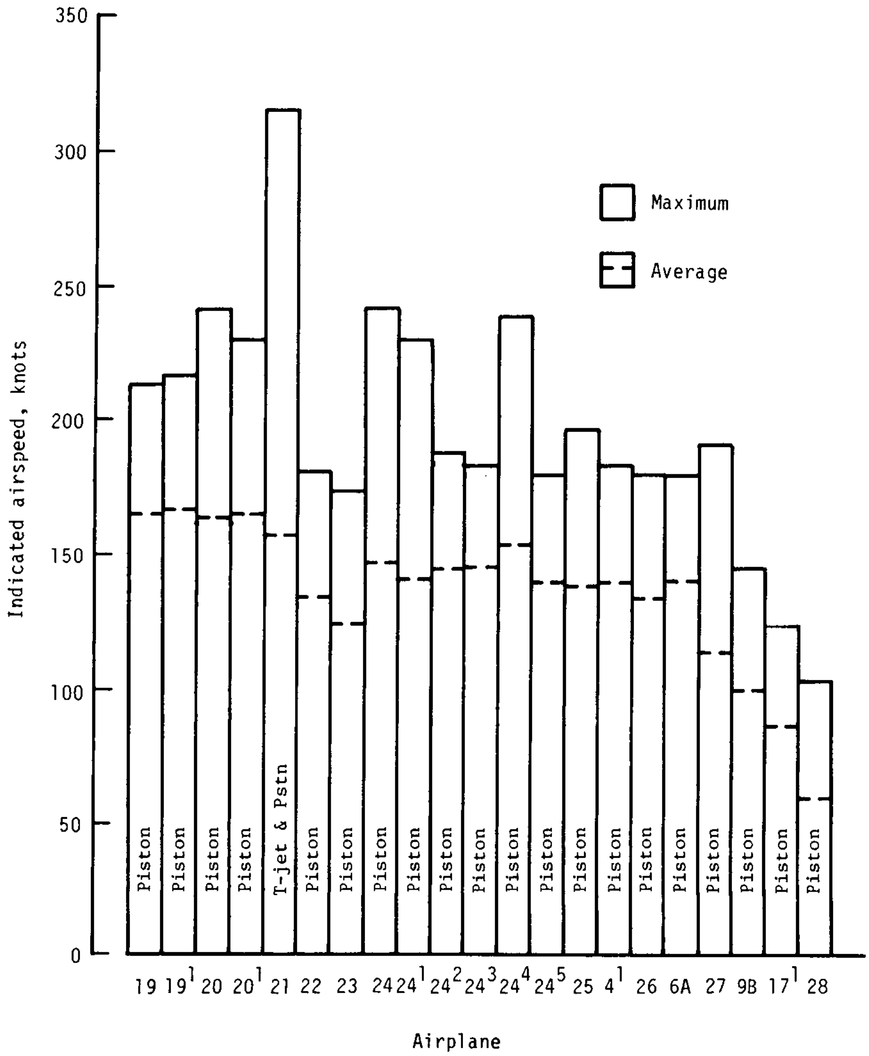
Figure 5.- Maximum and average indicated airspeeds recorded by individual airplanes flown in specified types of operations.



(c) Personal operations.

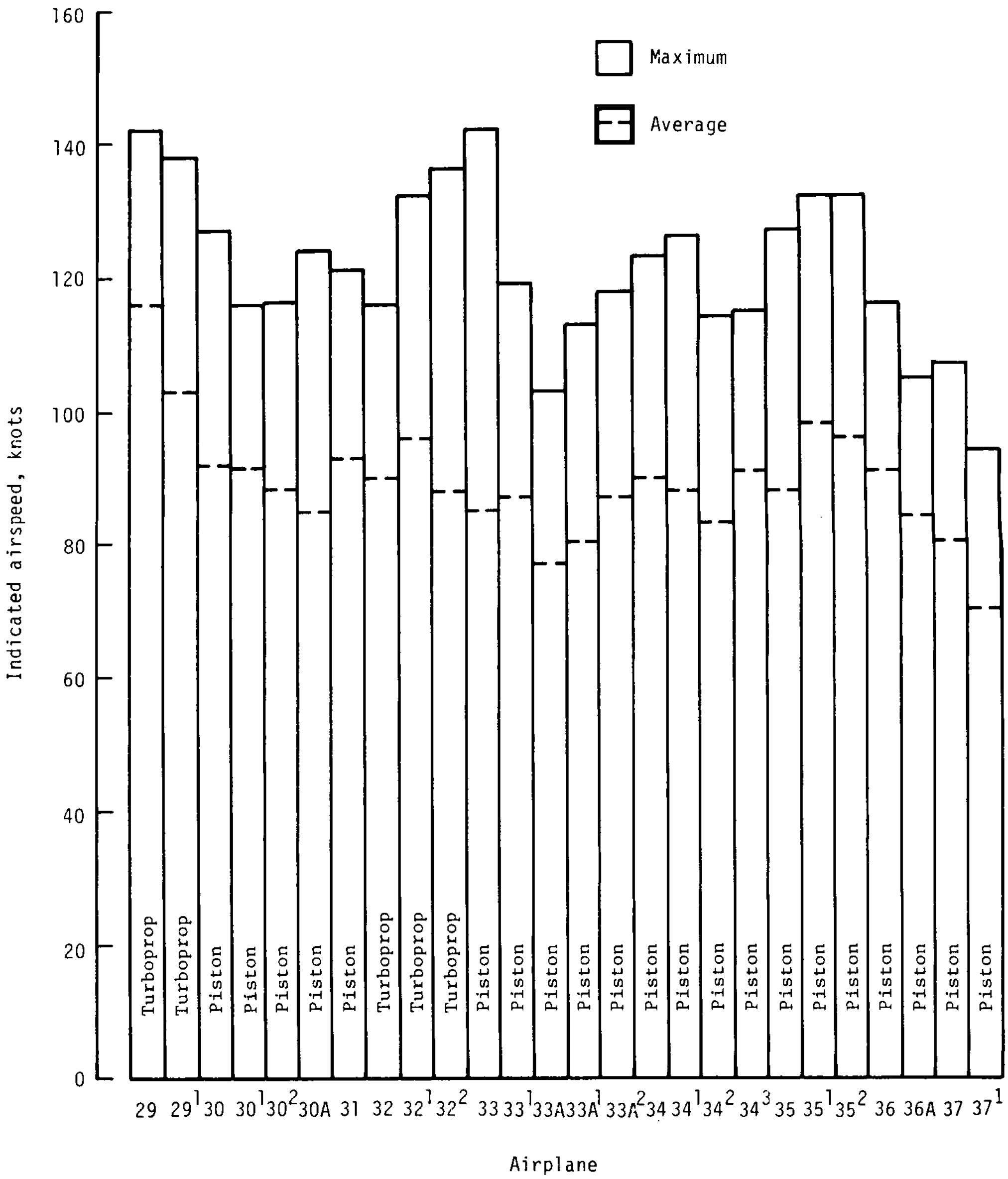
(d) Instructional operations.

Figure 5.- Continued.



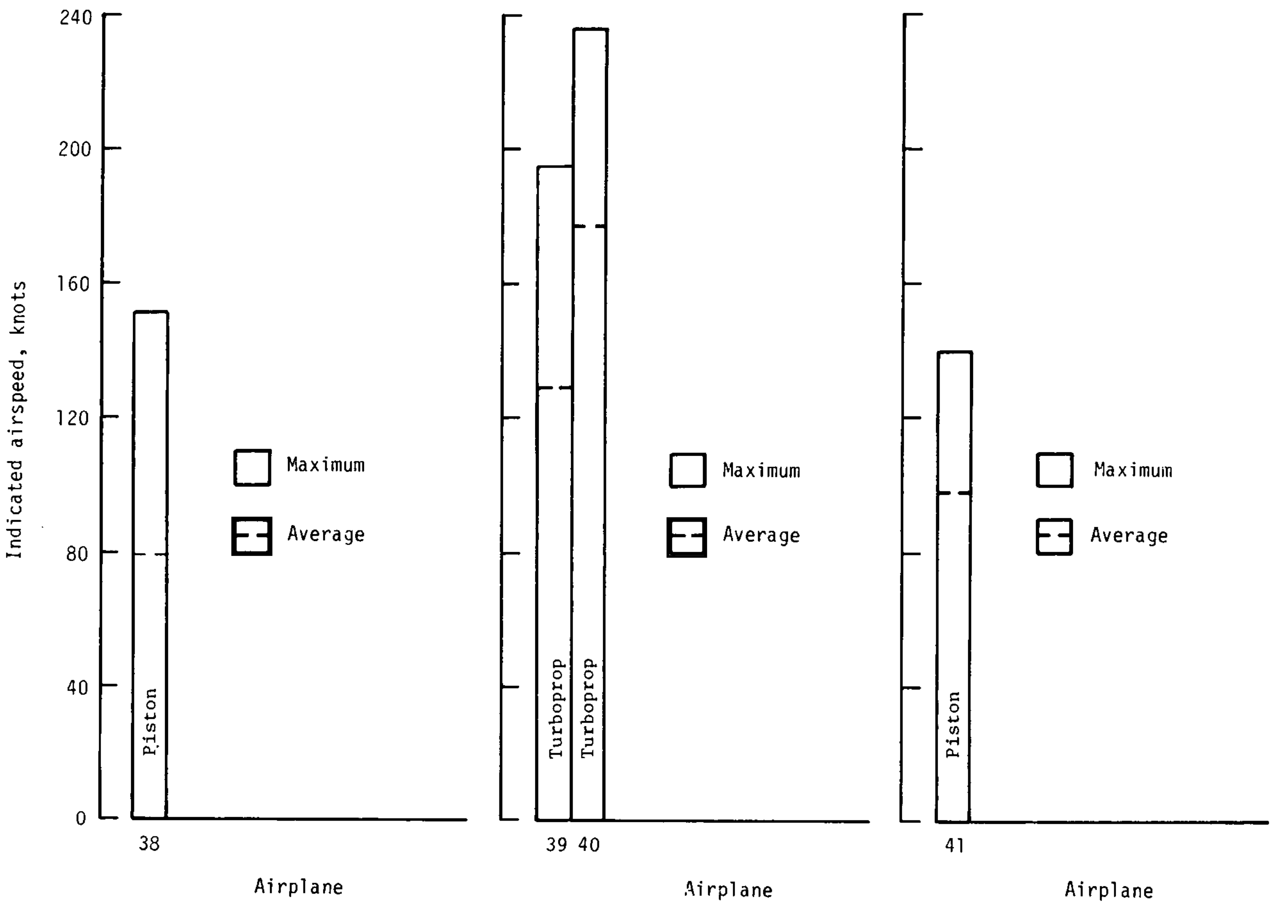
(e) Commercial survey operations.

Figure 5.- Continued.



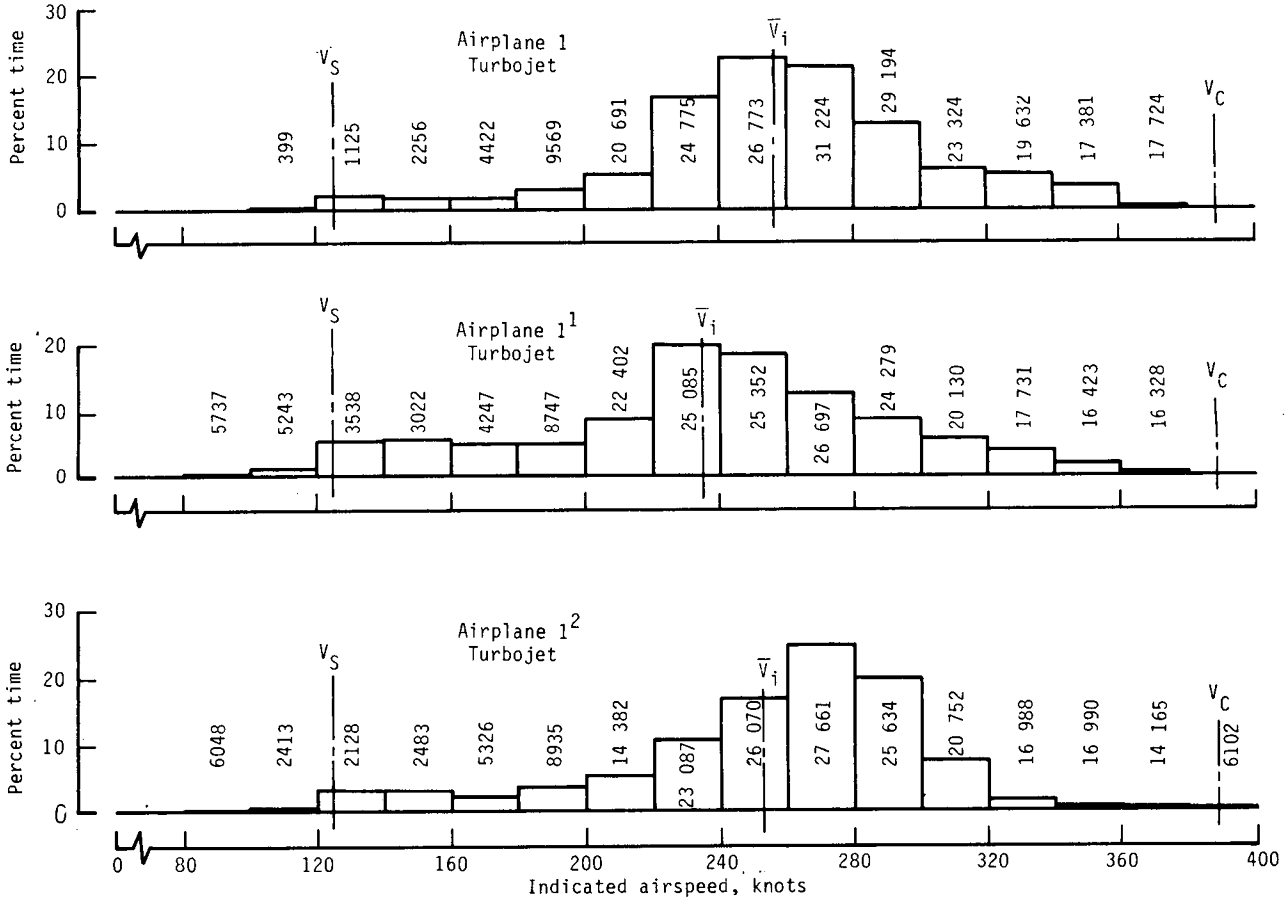
(f) Aerial application operations.

Figure 5.- Continued.



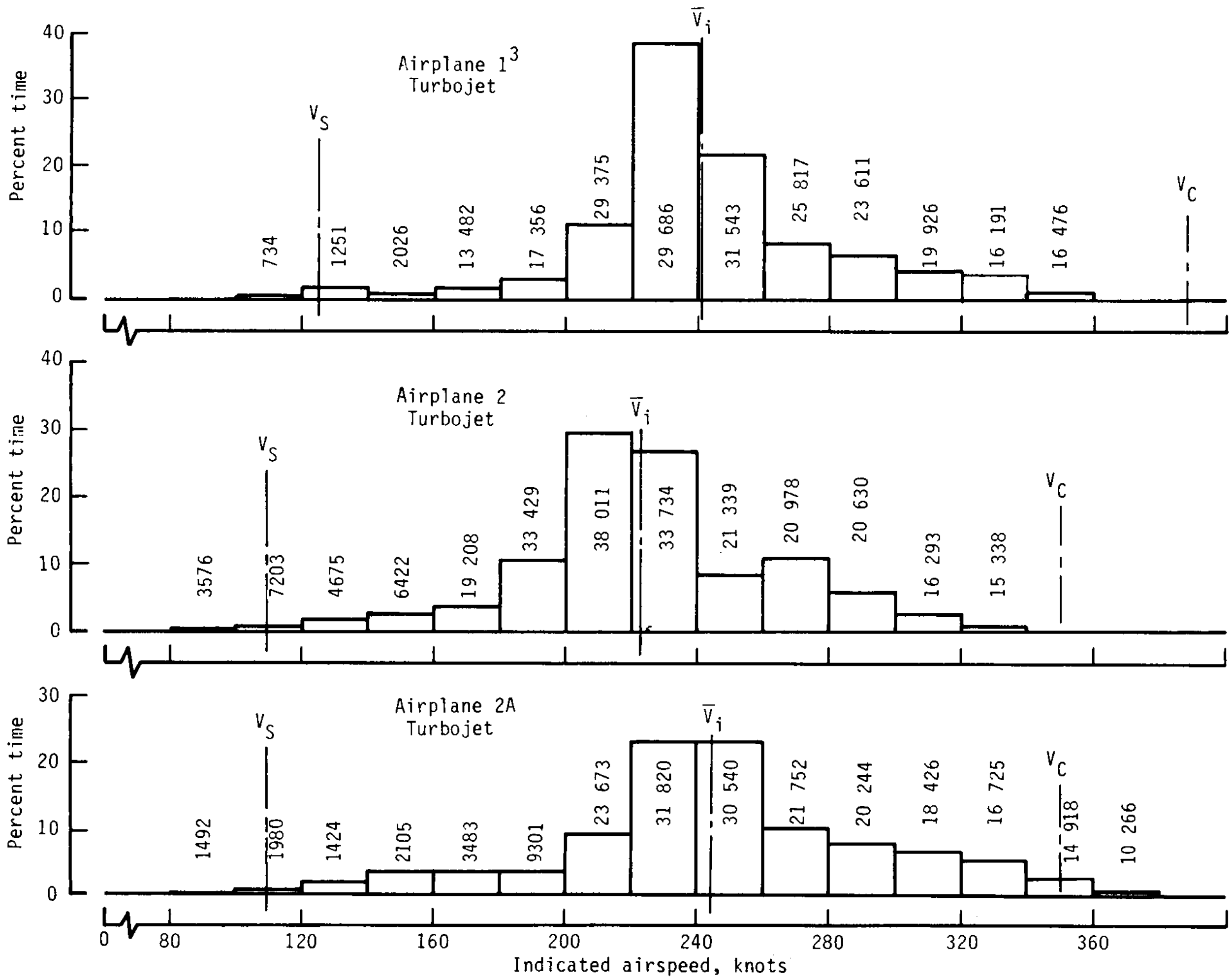
(g) Aerobatic operations. (h) Commuter operations. (i) Float operations.

Figure 5.- Concluded.



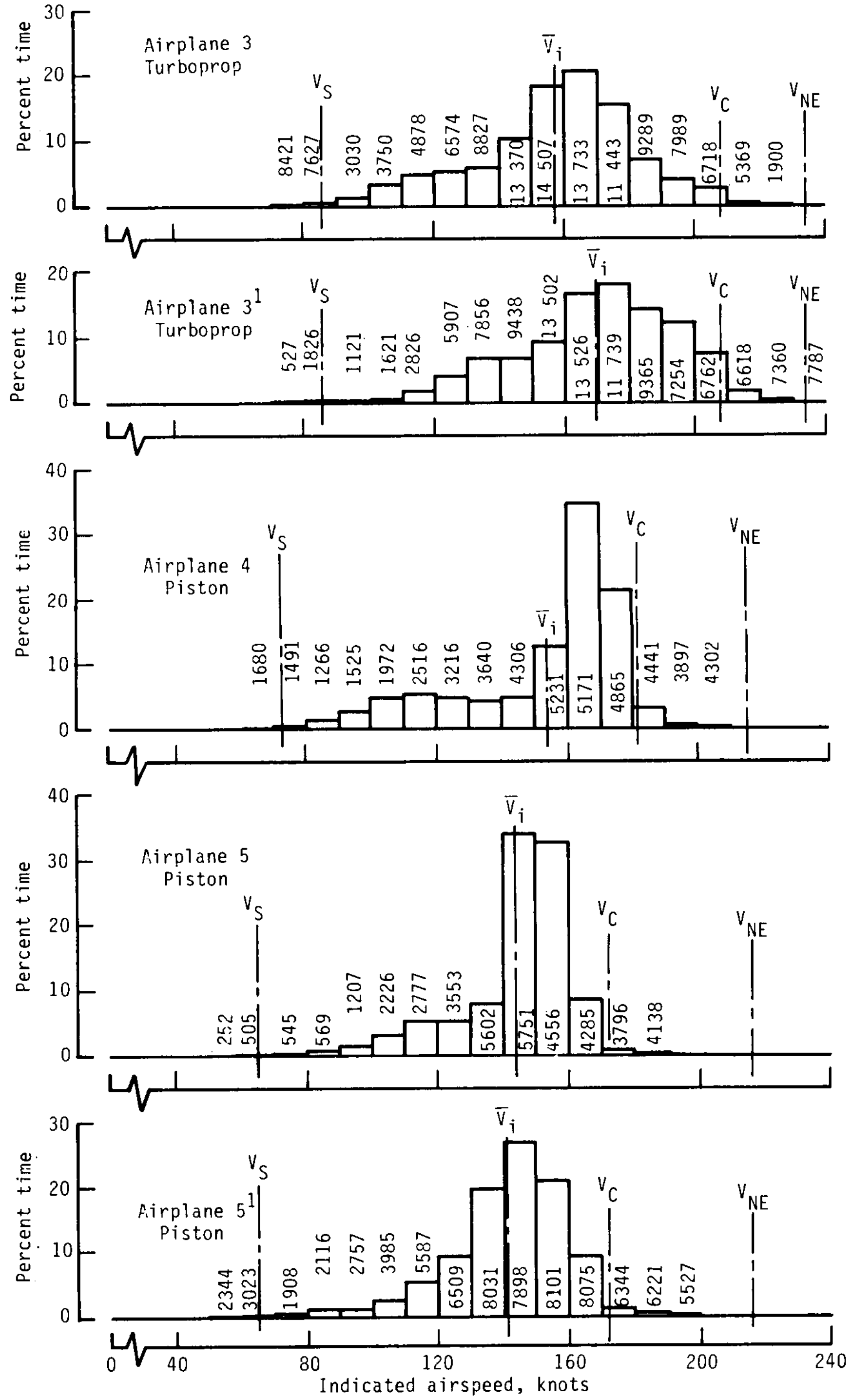
(a) Twin-engine executive operations.

Figure 6.- Percent of time flown in various airspeed intervals by airplanes in specified types of operations. Average altitudes recorded in each airspeed interval are also noted.



(a) Continued.

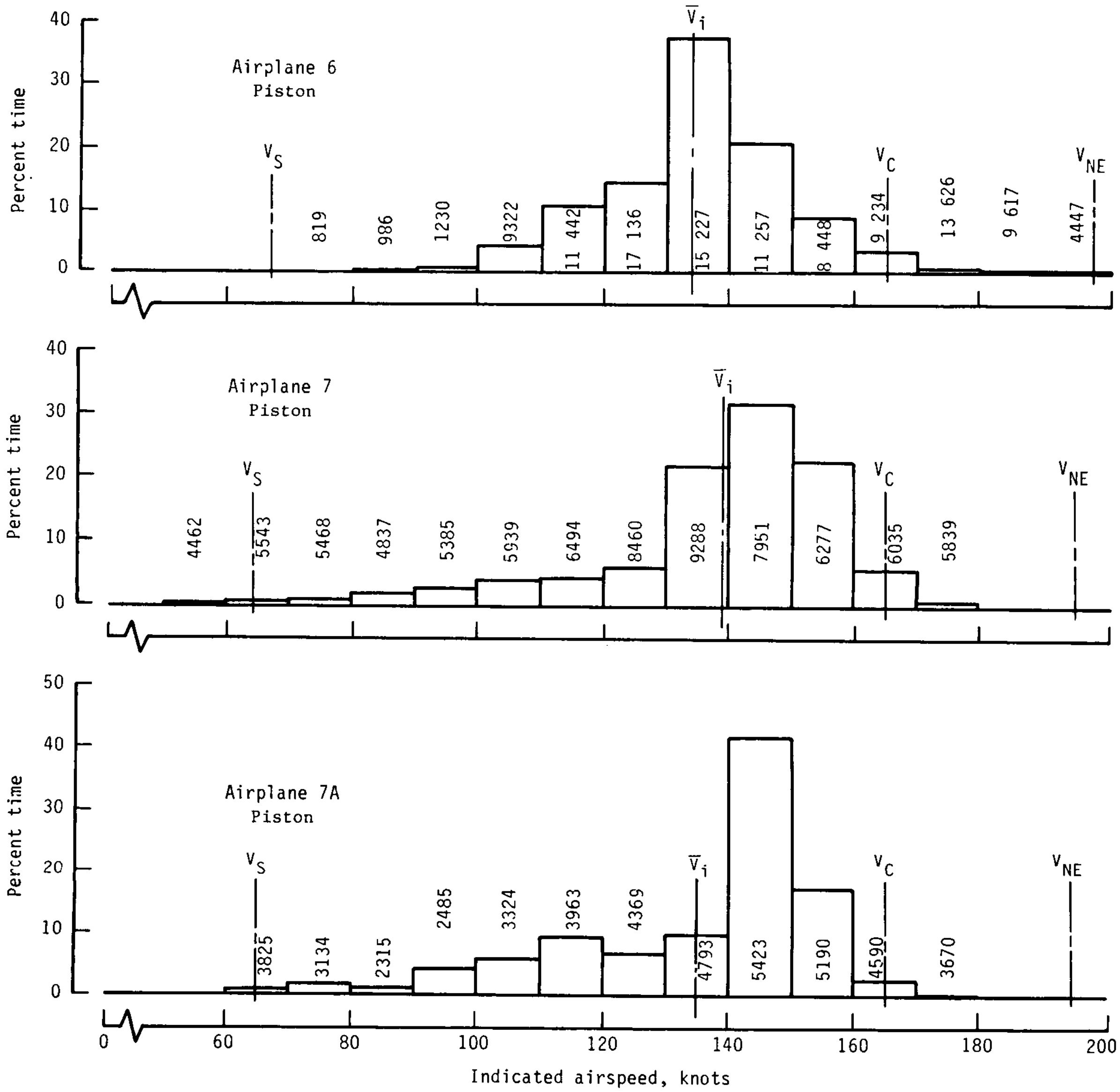
Figure 6.- Continued.



(a) Concluded.

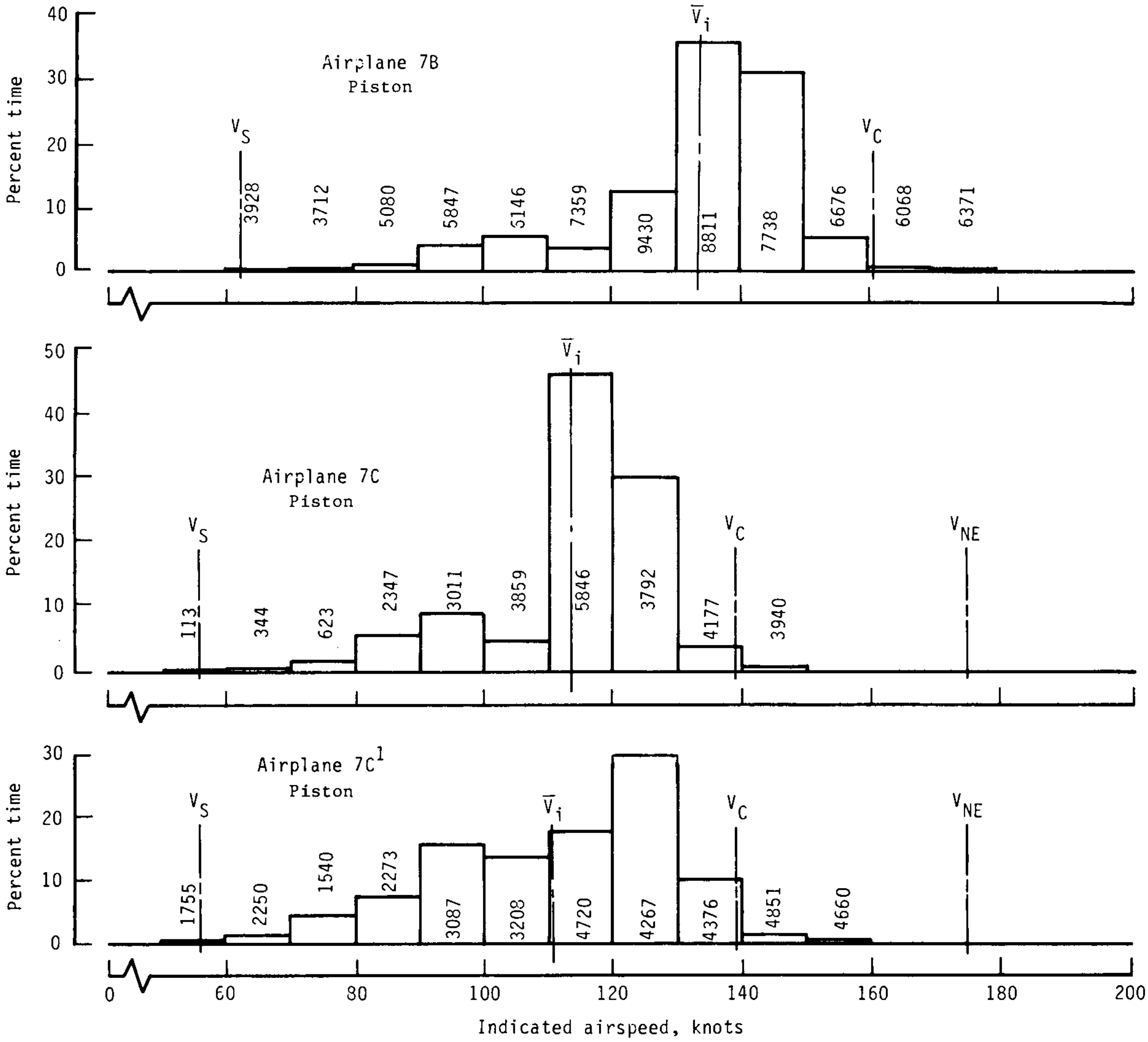
Figure 6.- Continued.

C-2



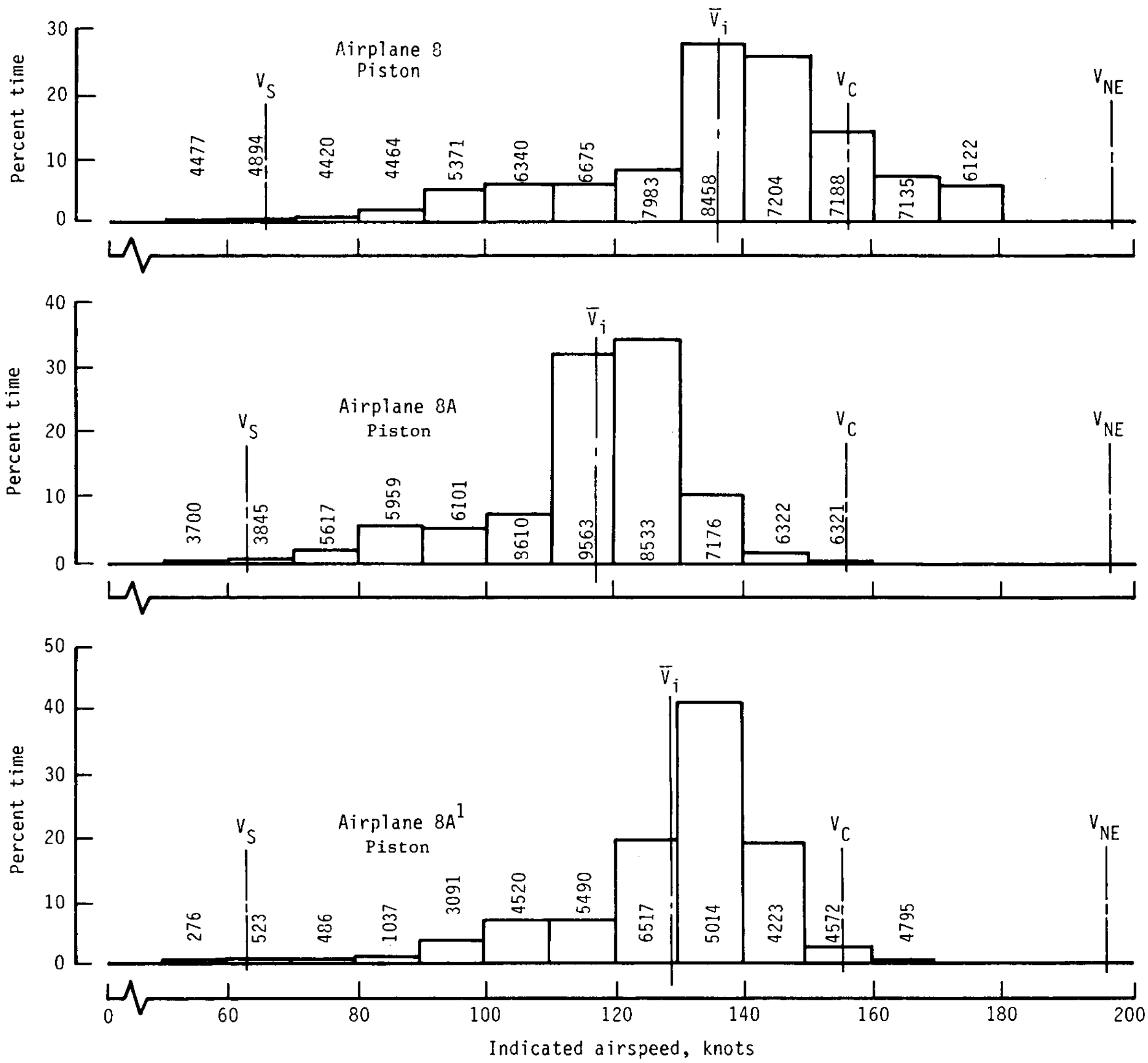
(b) Single-engine executive operations.

Figure 6.- Continued.



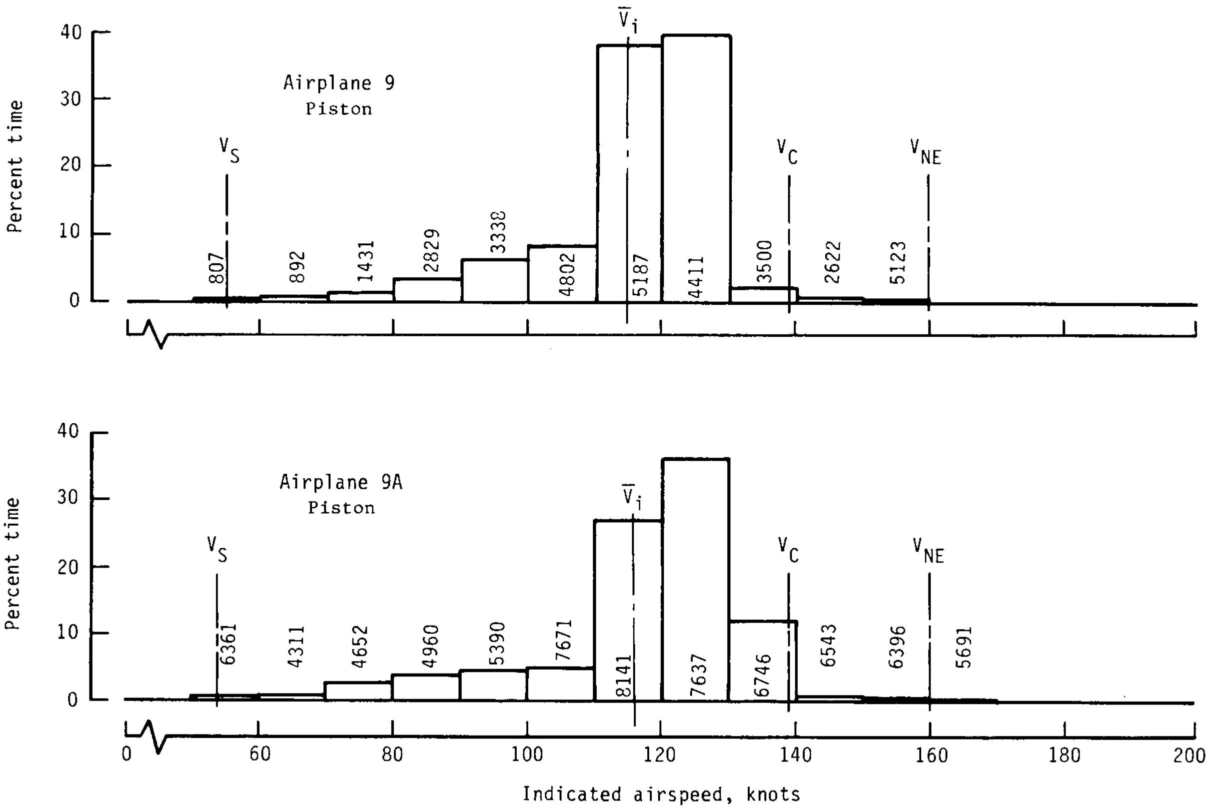
(b) Continued.

Figure 6.- Continued.



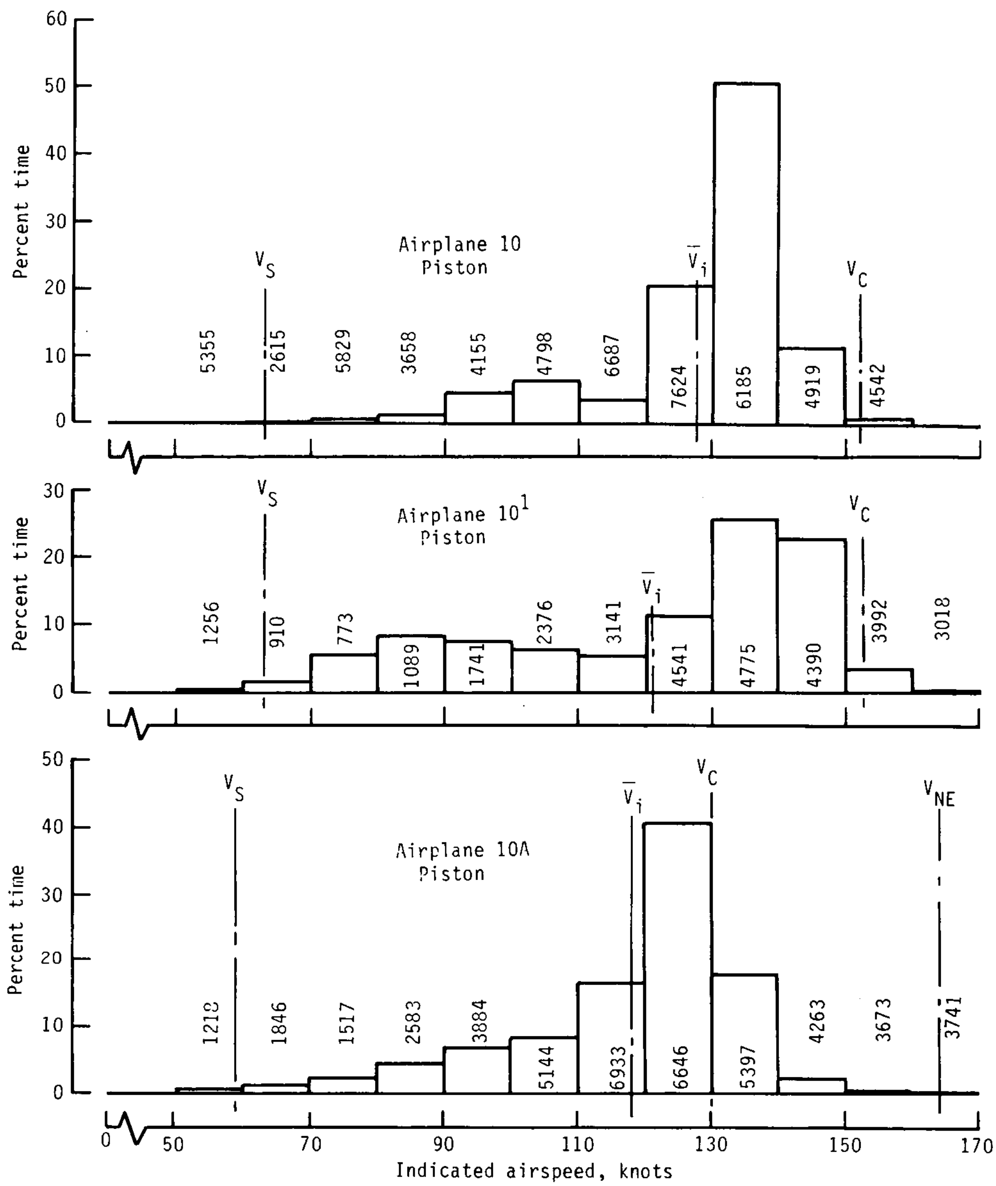
(b) Continued.

Figure 6.- Continued.



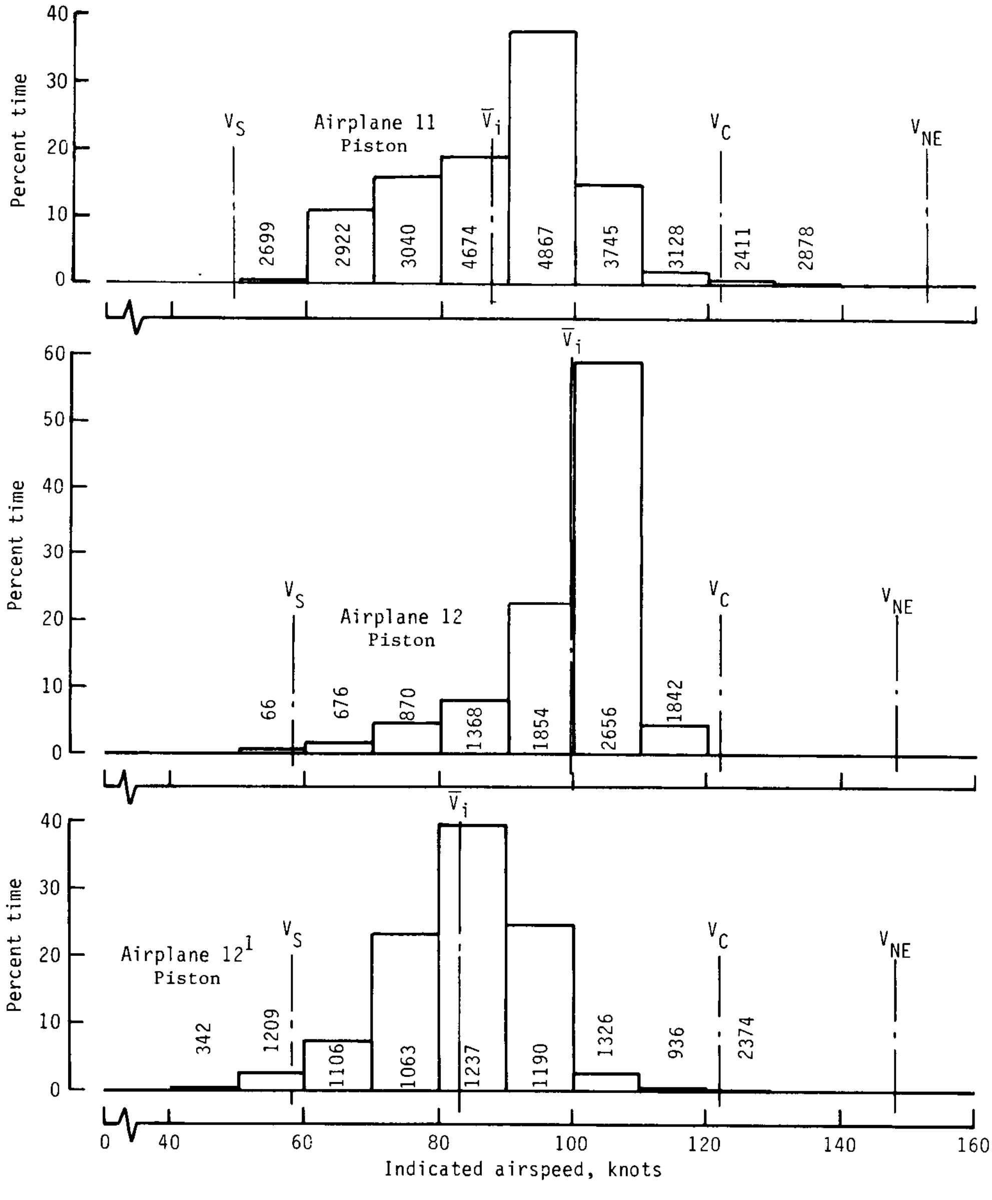
(b) Concluded.

Figure 6.- Continued.



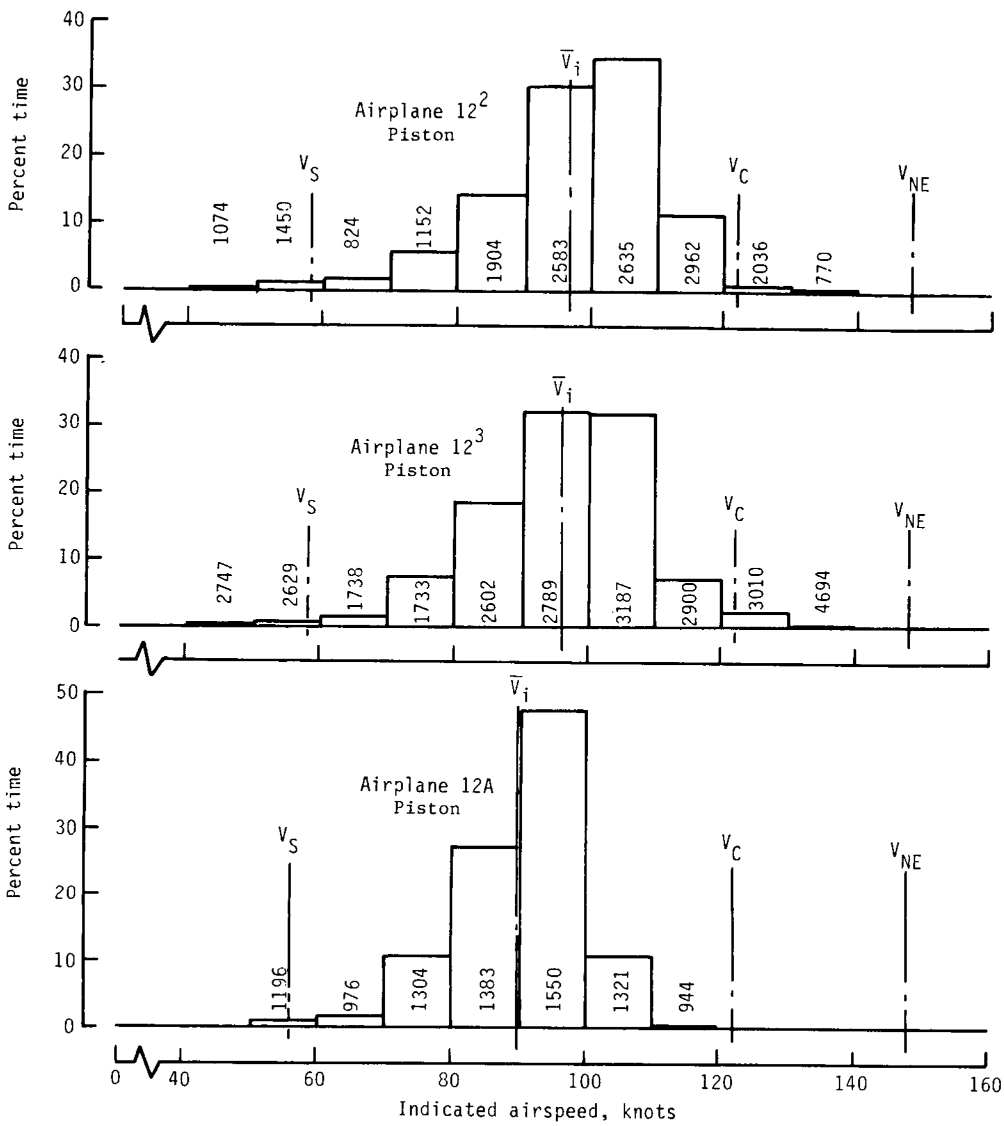
(c) Personal operations.

Figure 6.- Continued.



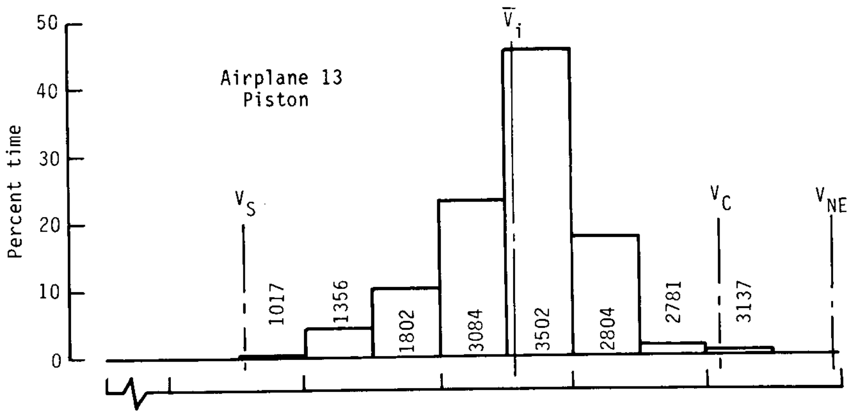
(c) Continued.

Figure 6.- Continued.



(c) Continued.

Figure 6.- Continued.



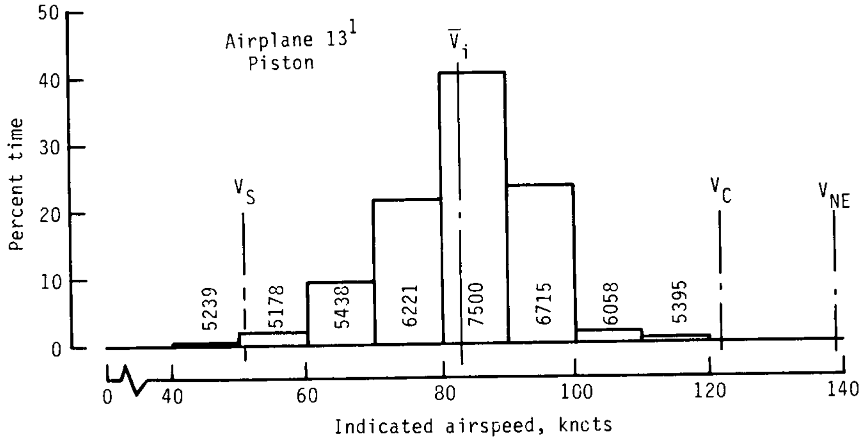


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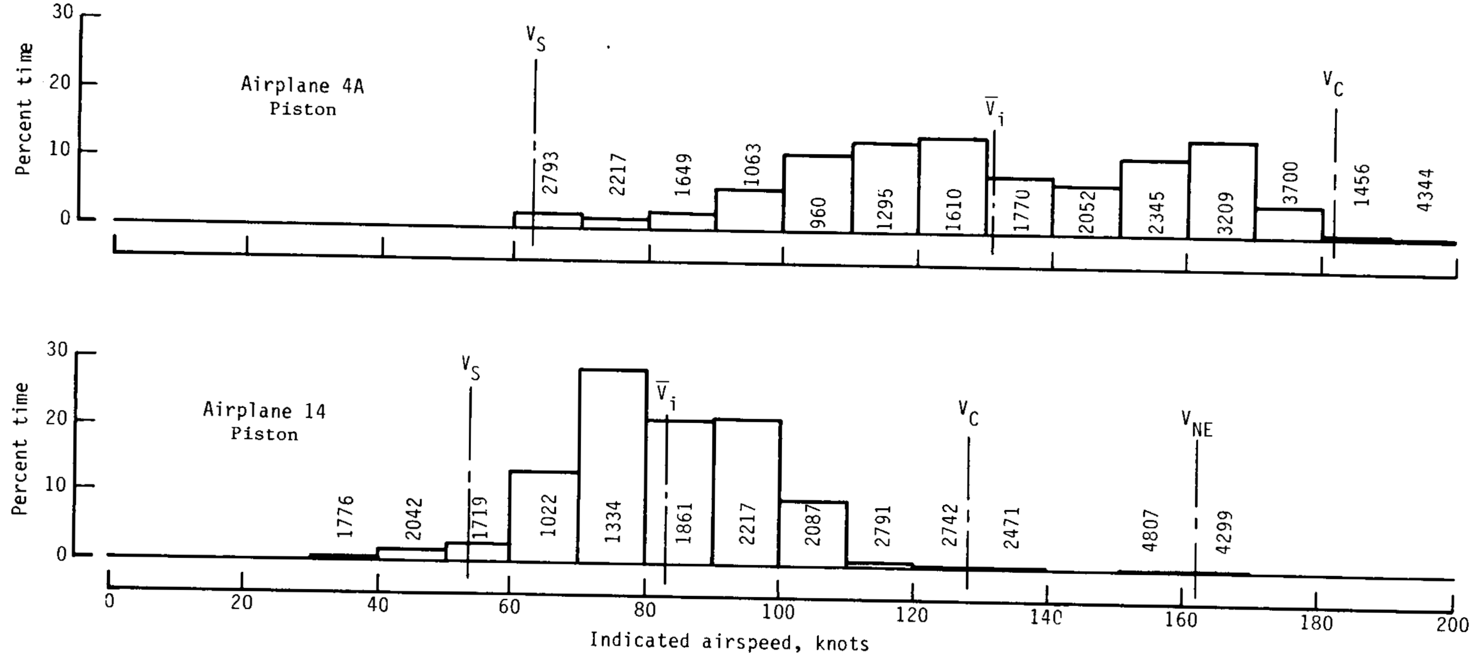
Figure 6.- Continued.



(d) Instructional operations.

Figure 6.- Continued.

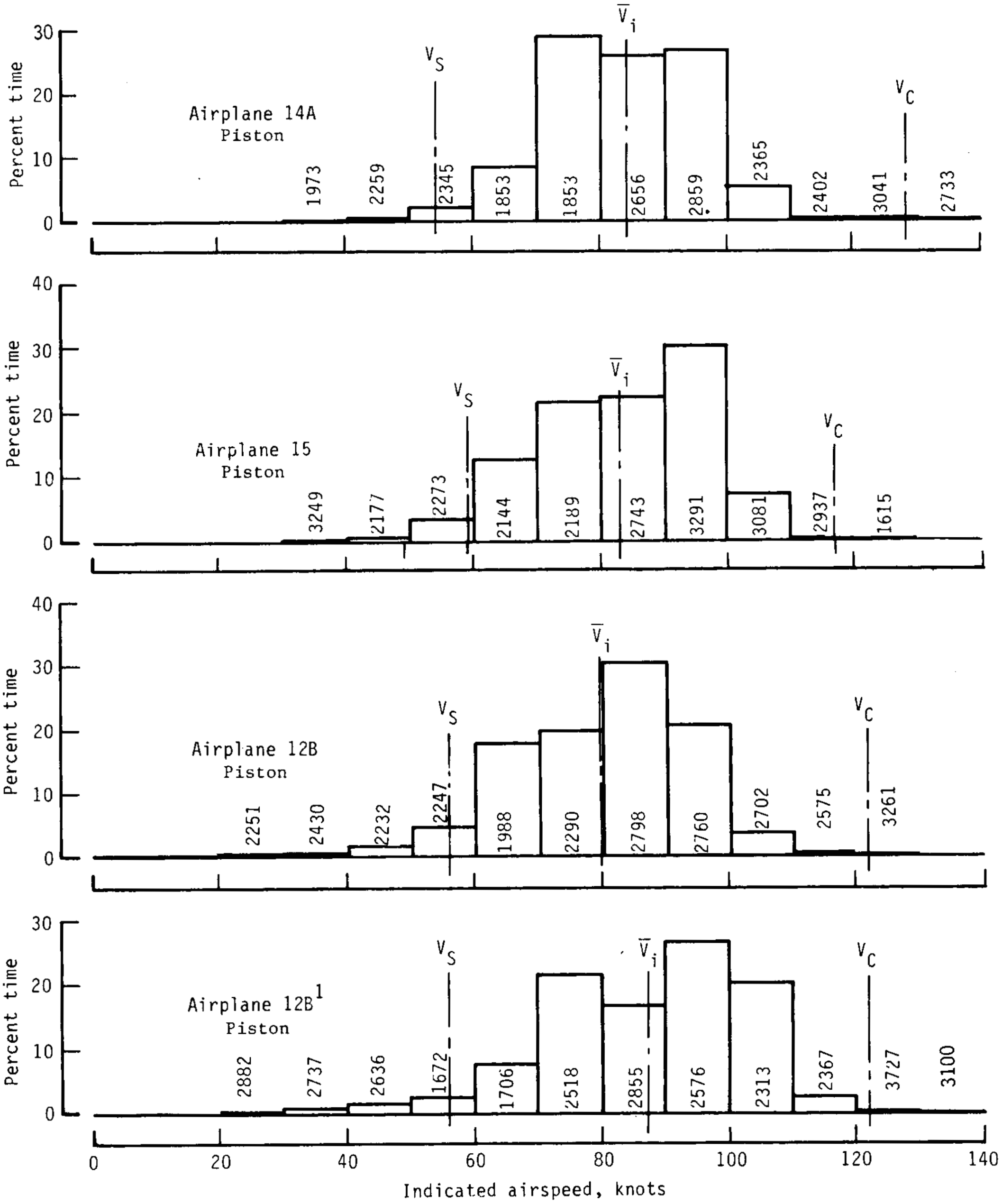


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Figure 6.- Continued.

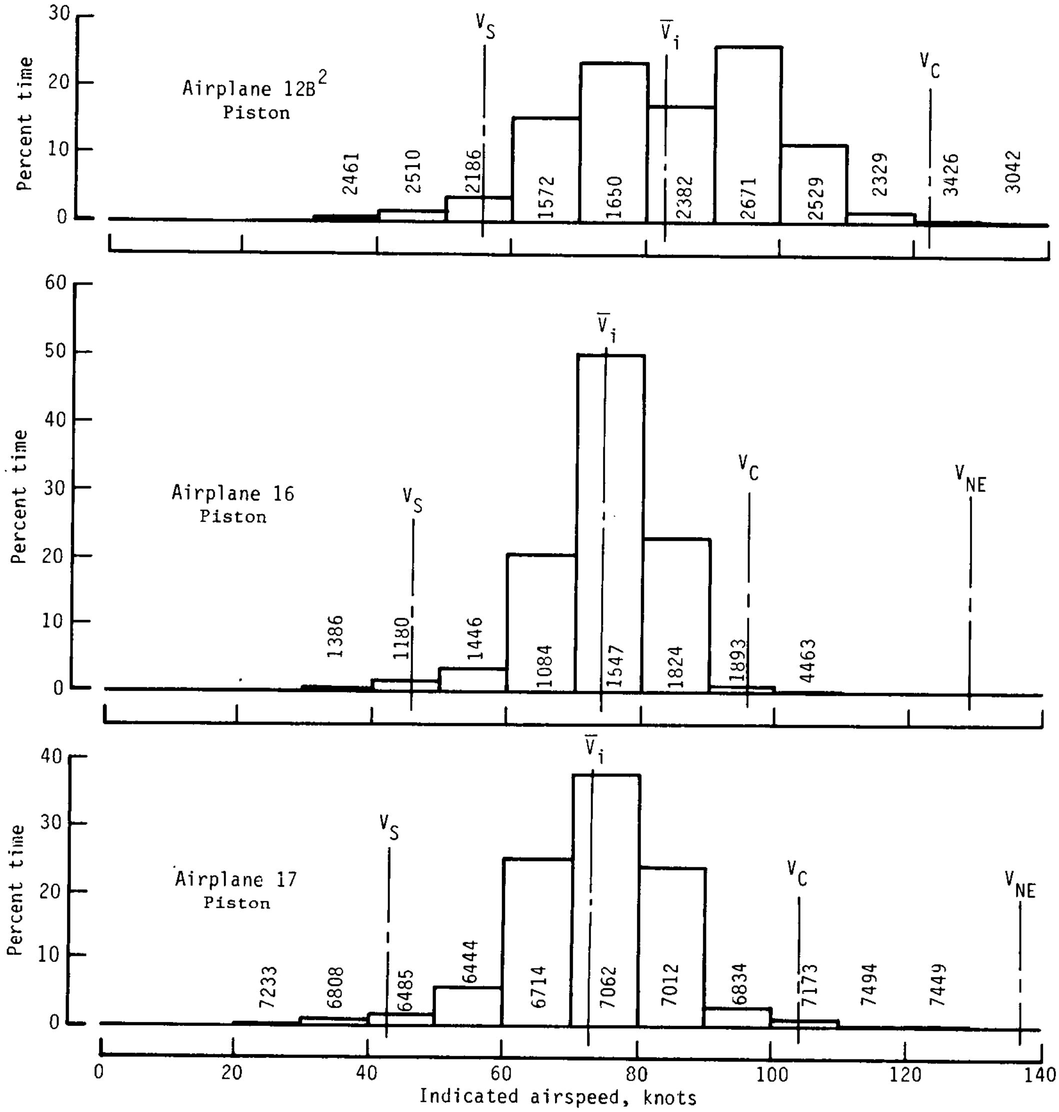

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Figure 6.- Continued.

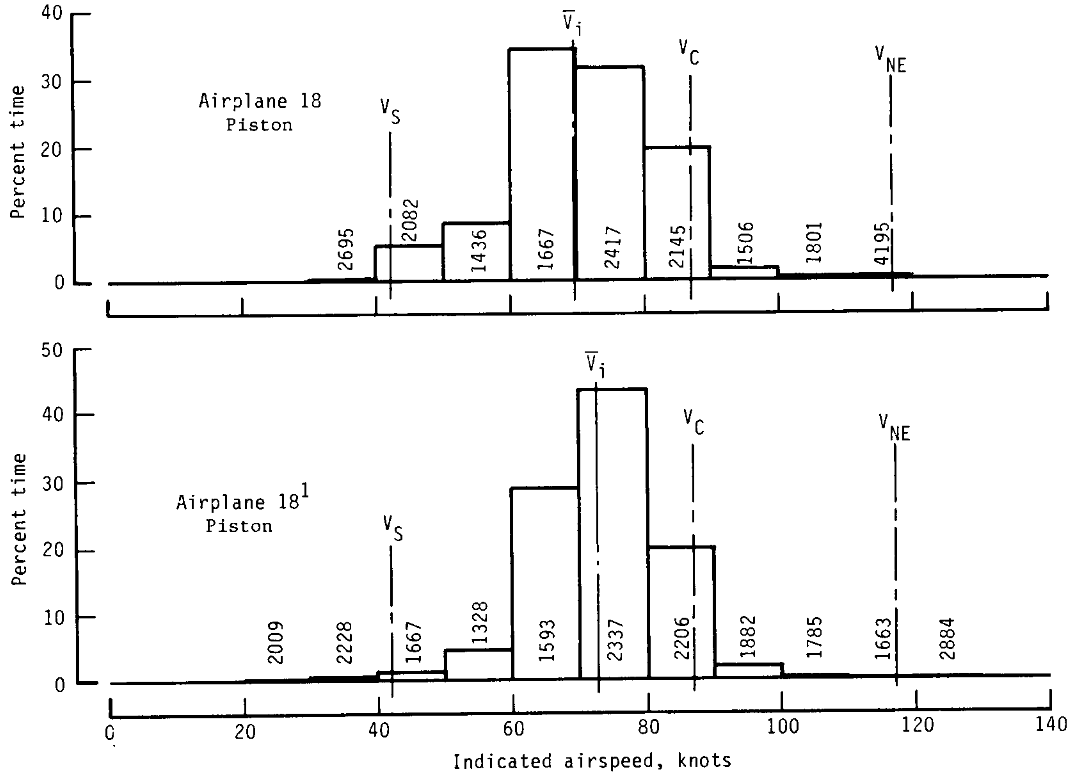

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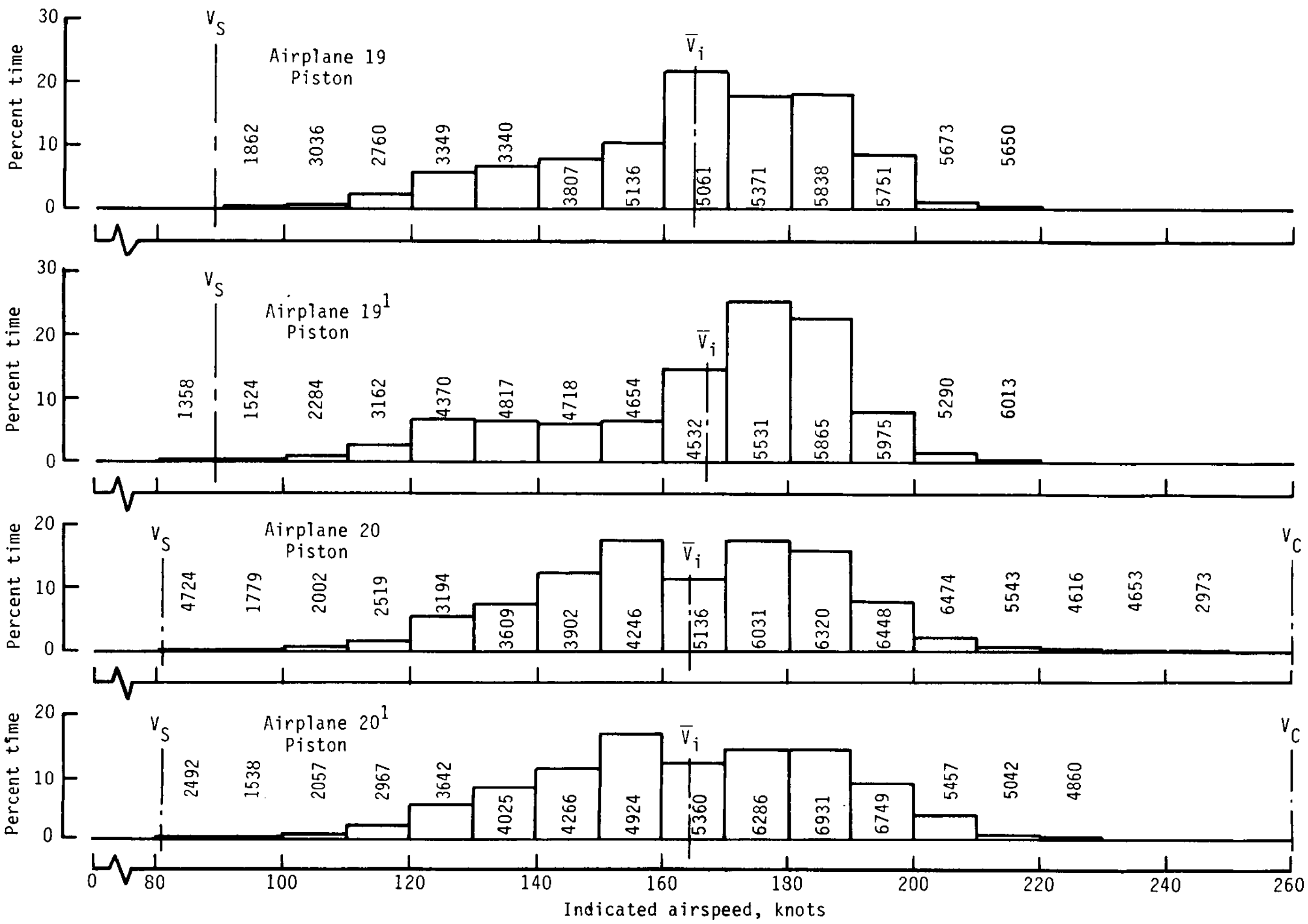
Figure 6.- Continued.



(e) Commercial survey operations.

Figure 6.- Continued.

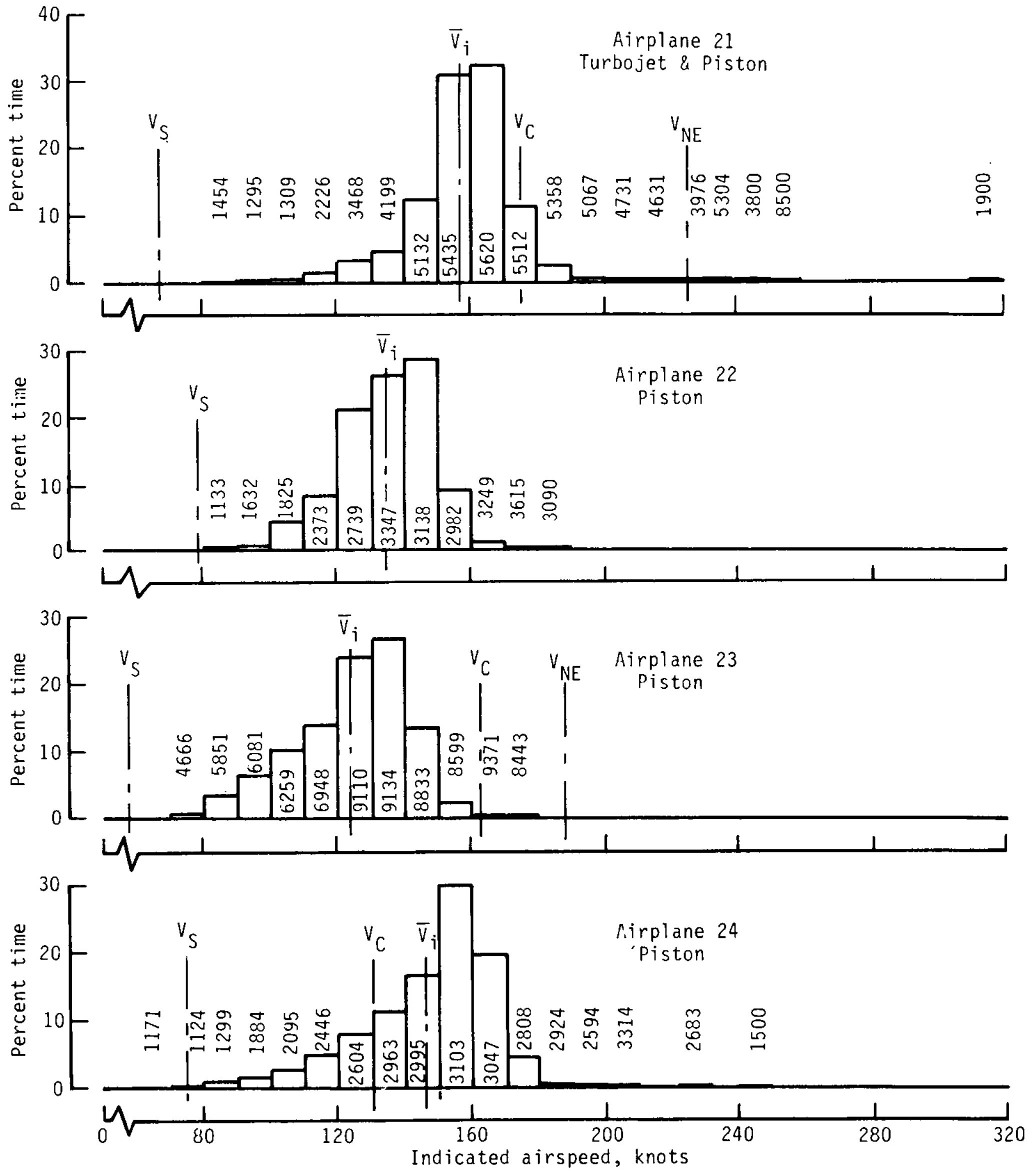


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Figure 6.- Continued.

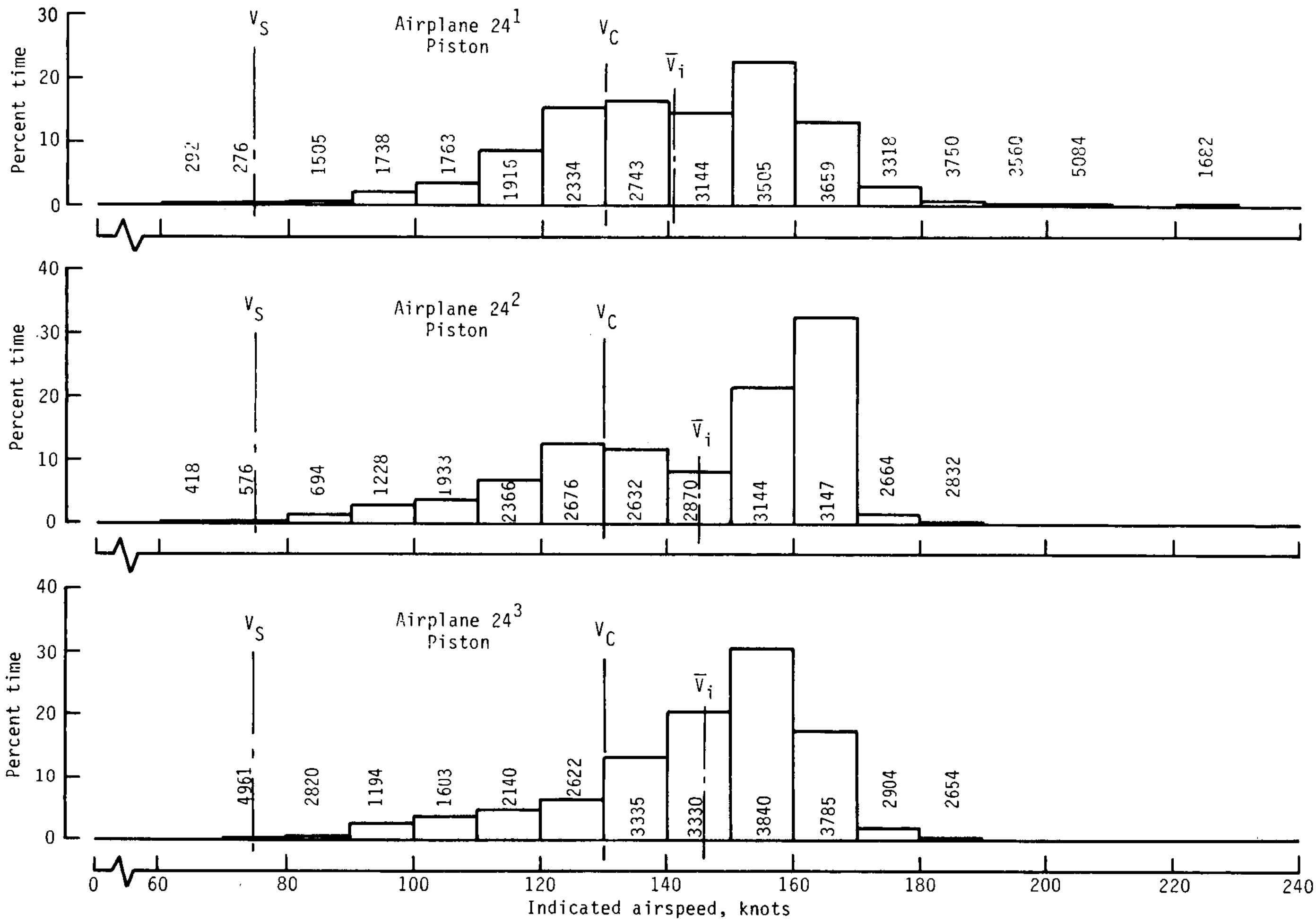

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Figure 6.- Continued.

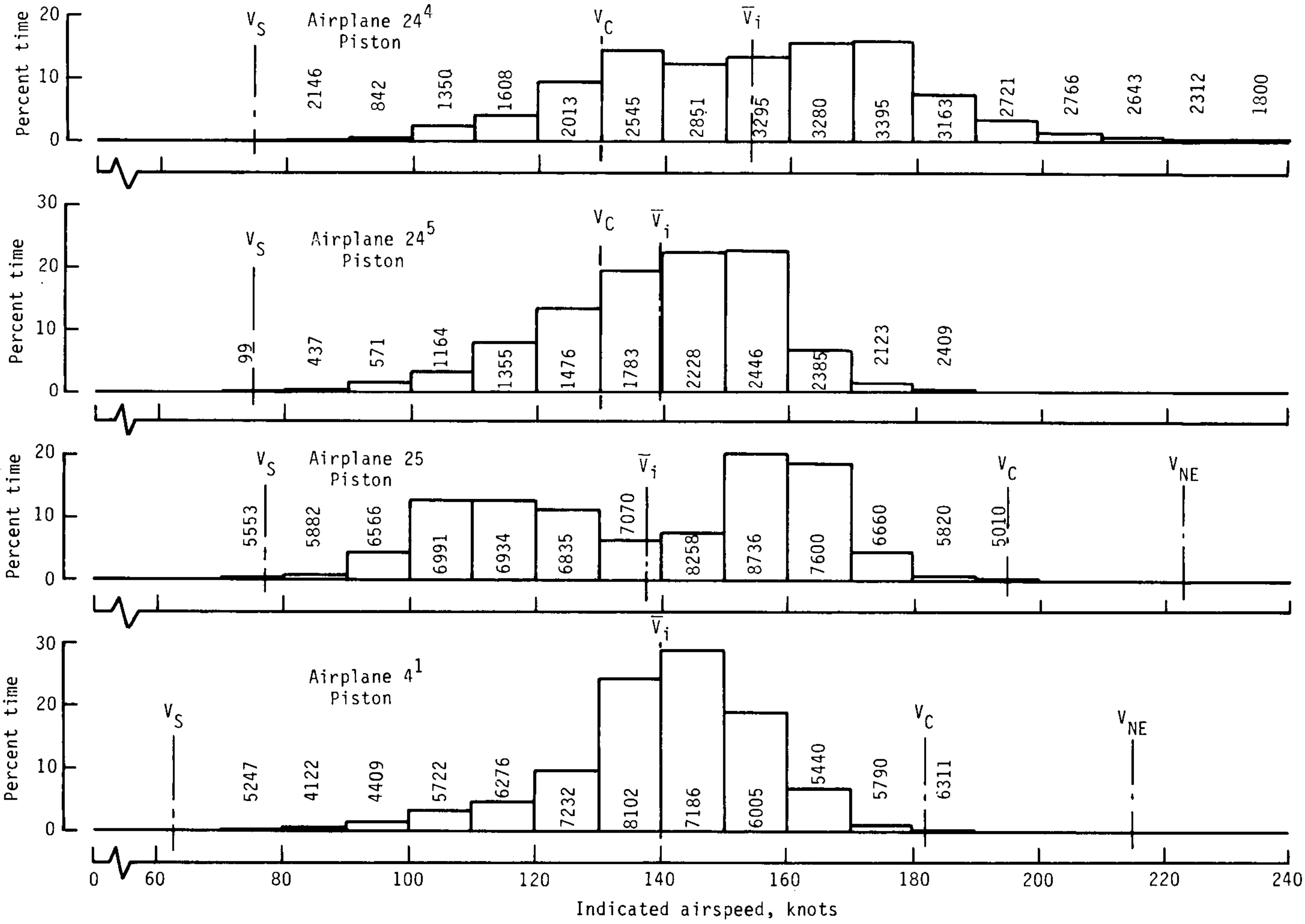

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Figure 6.- Continued.

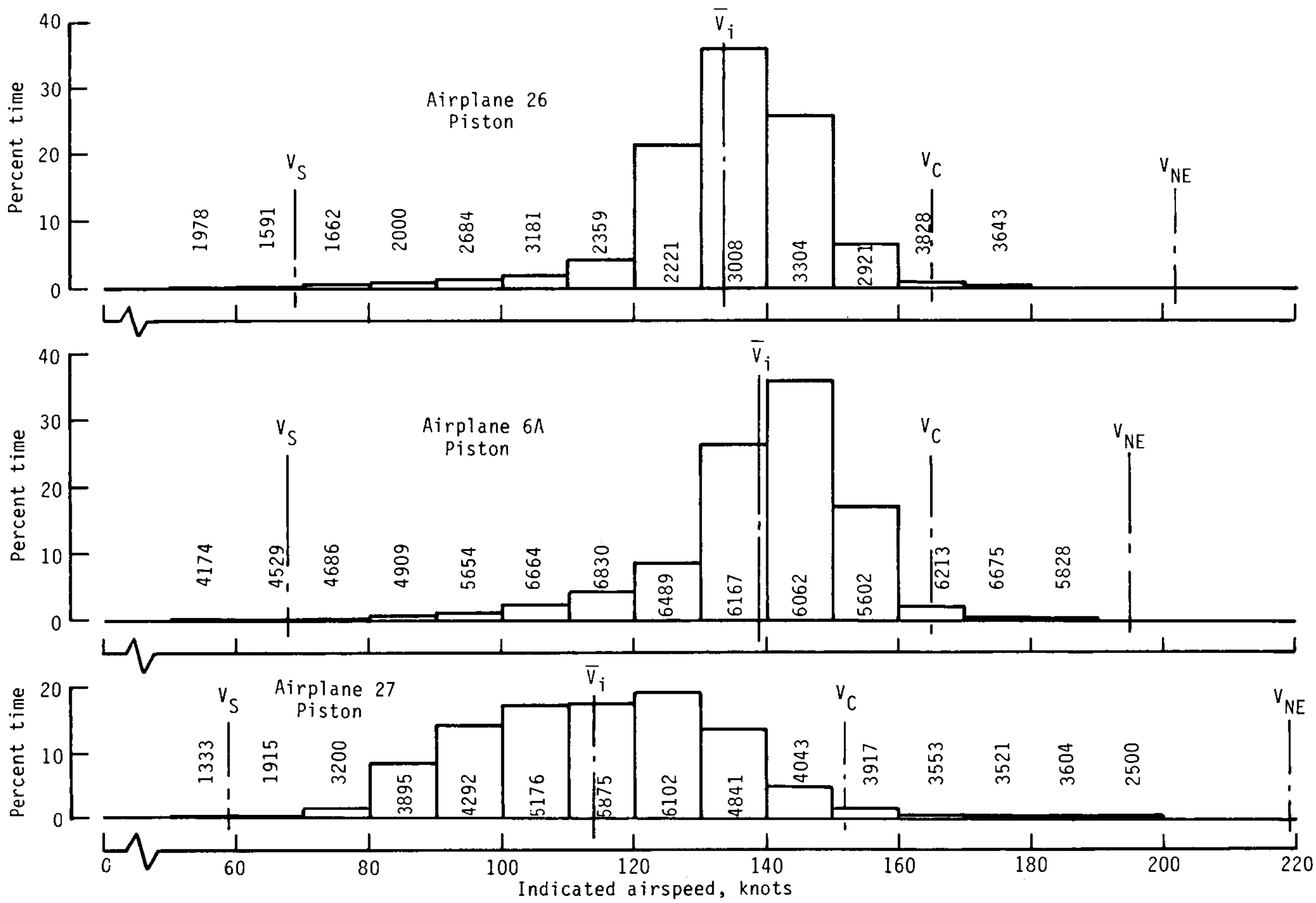

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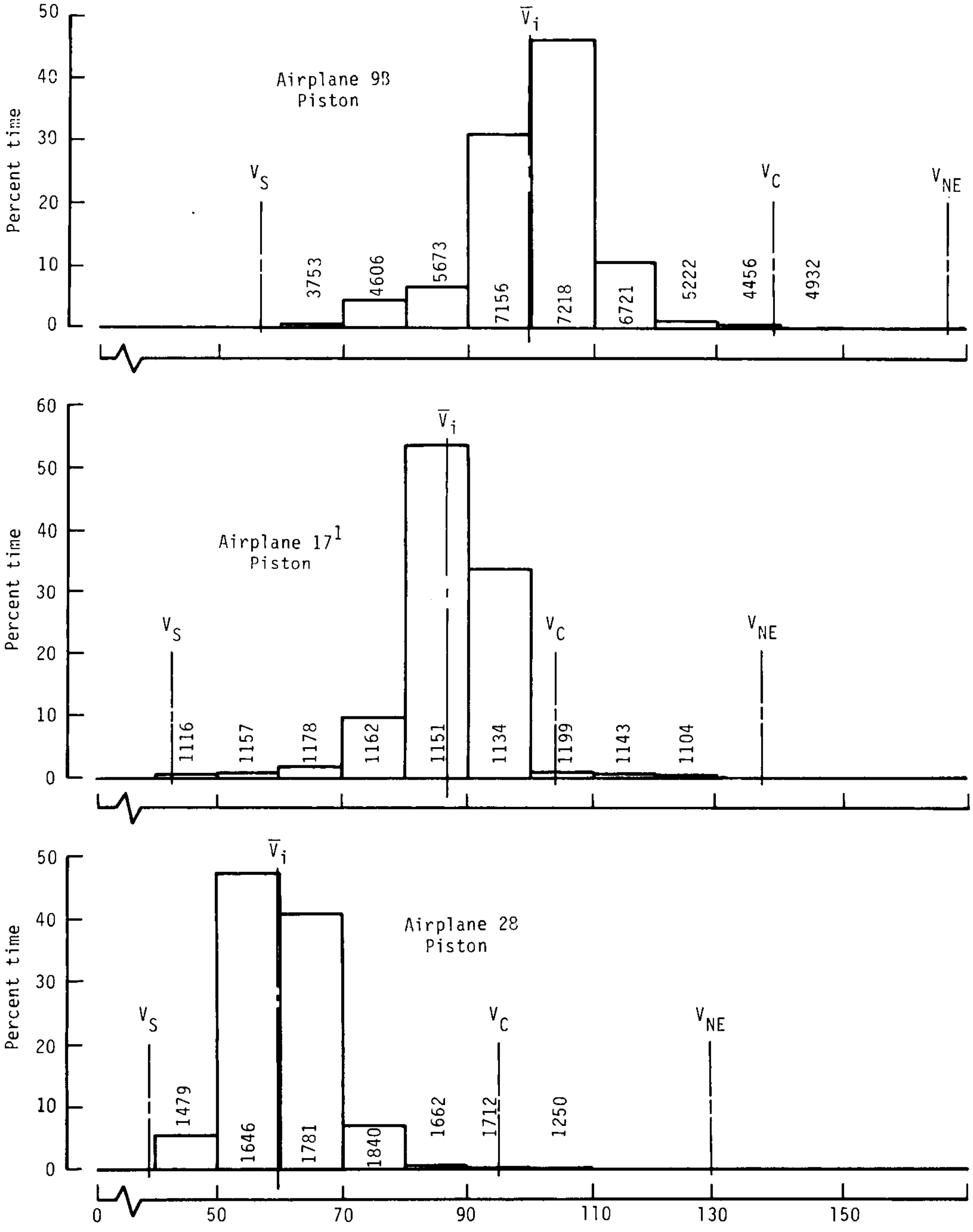
Figure 6.- Continued.



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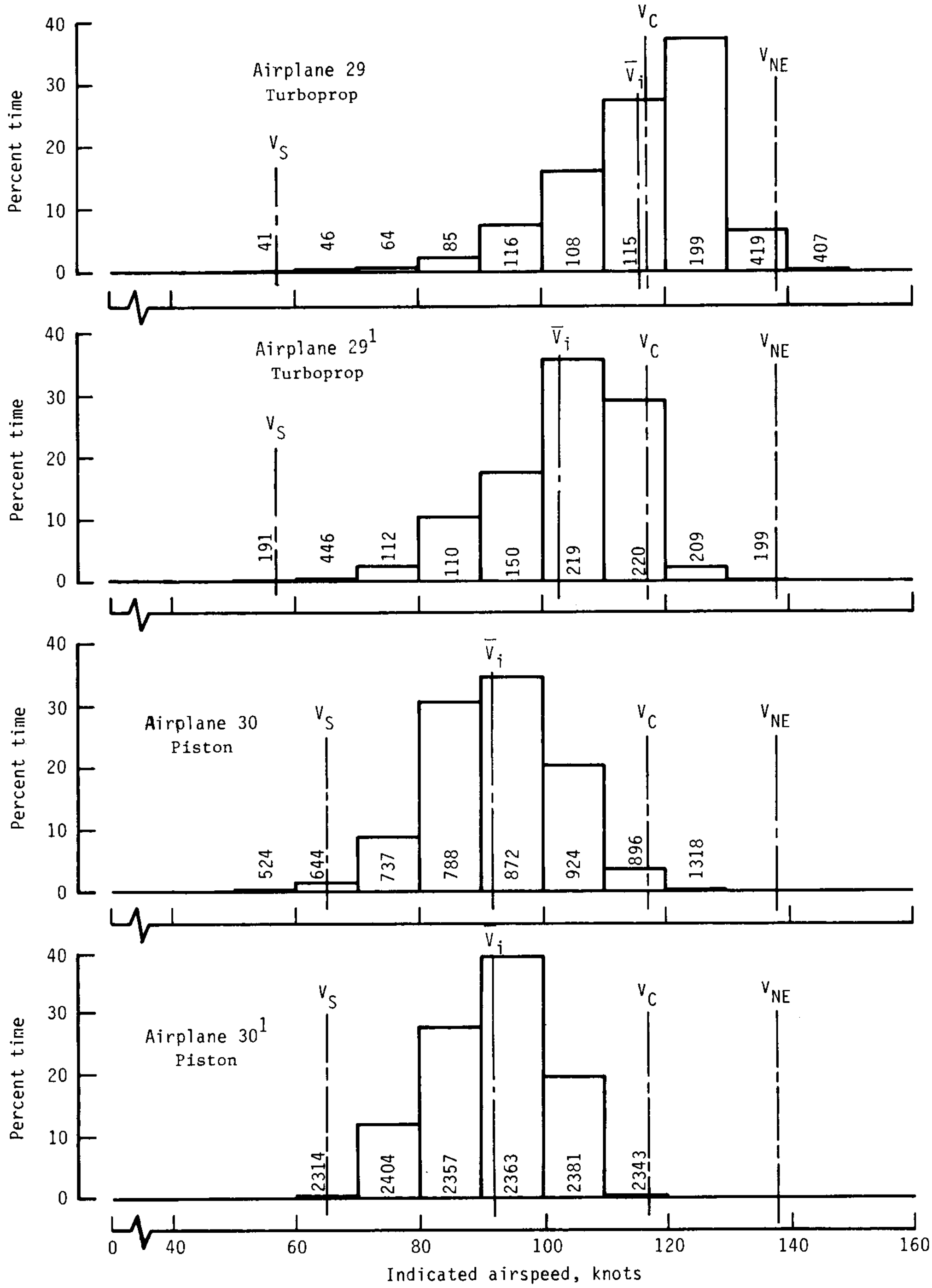

(f) Aerial application operations.

Figure 6.- Continued.

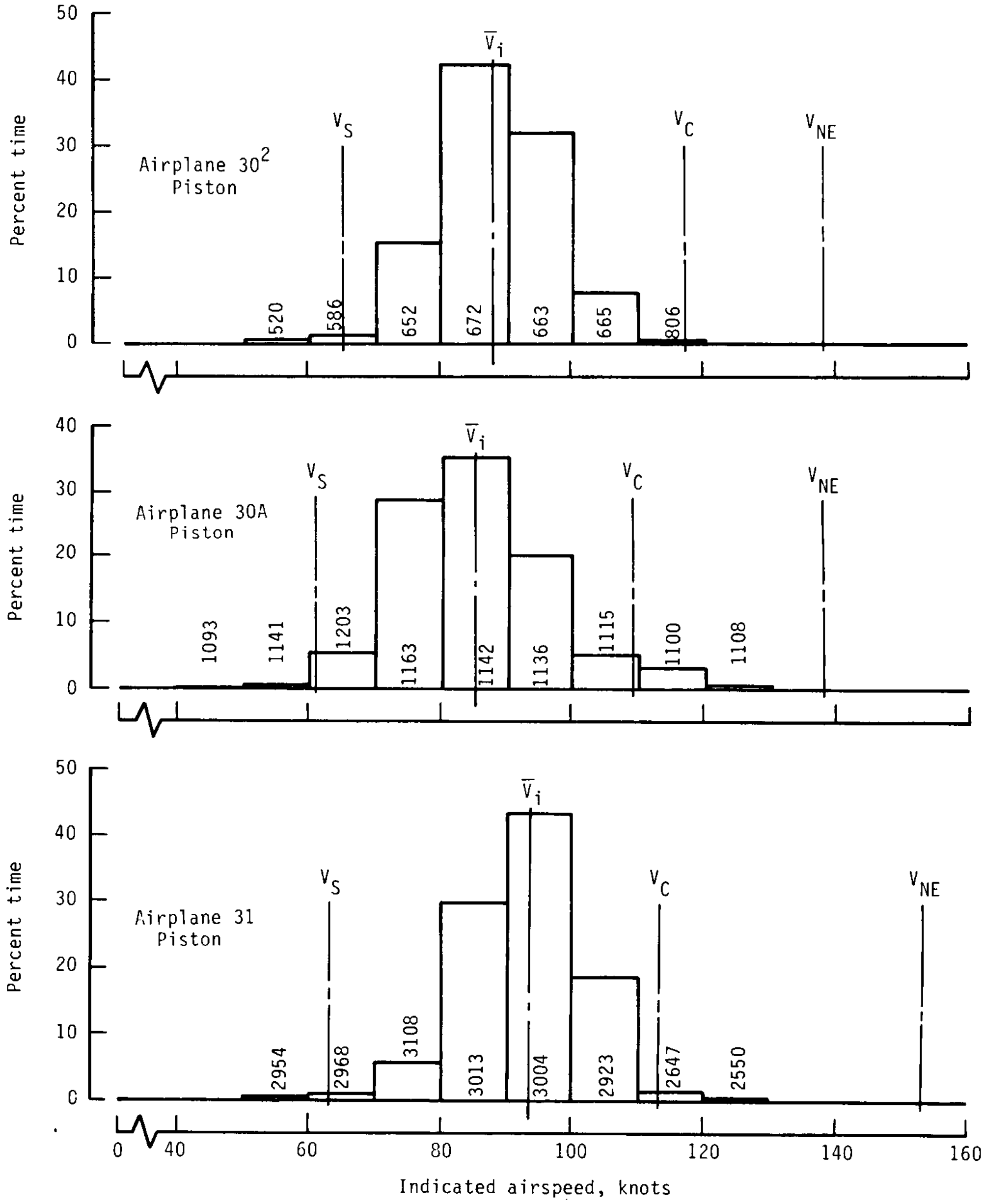

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Figure 6.- Continued.

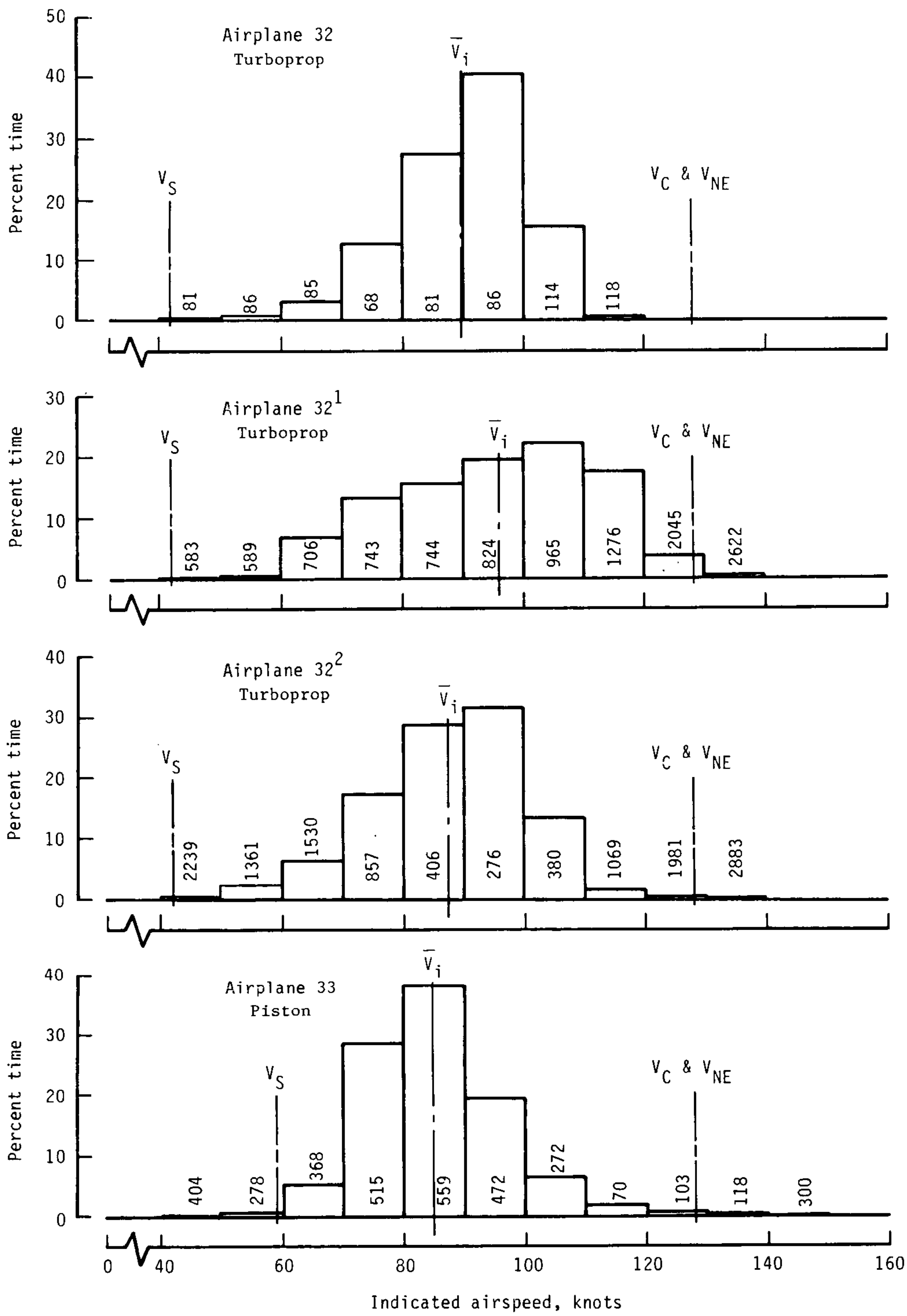

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Figure 6.- Continued.

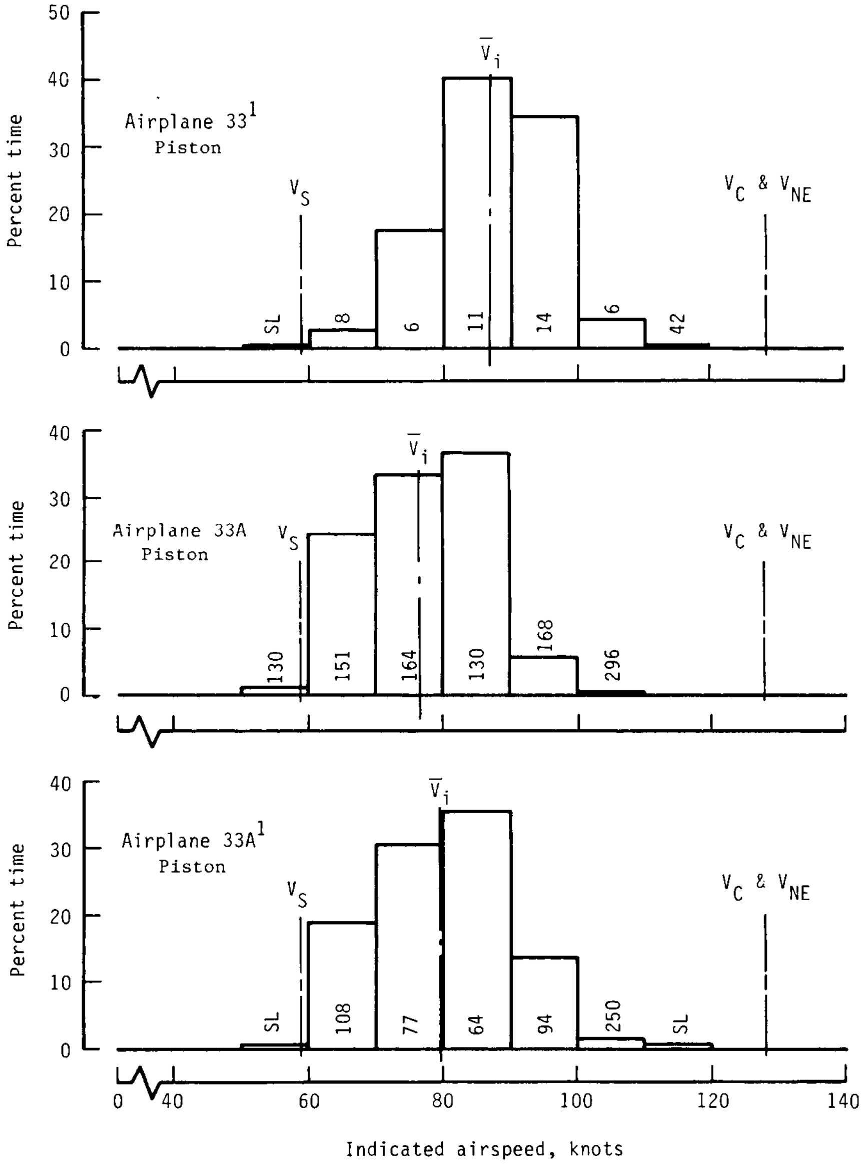

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Figure 6.- Continued.

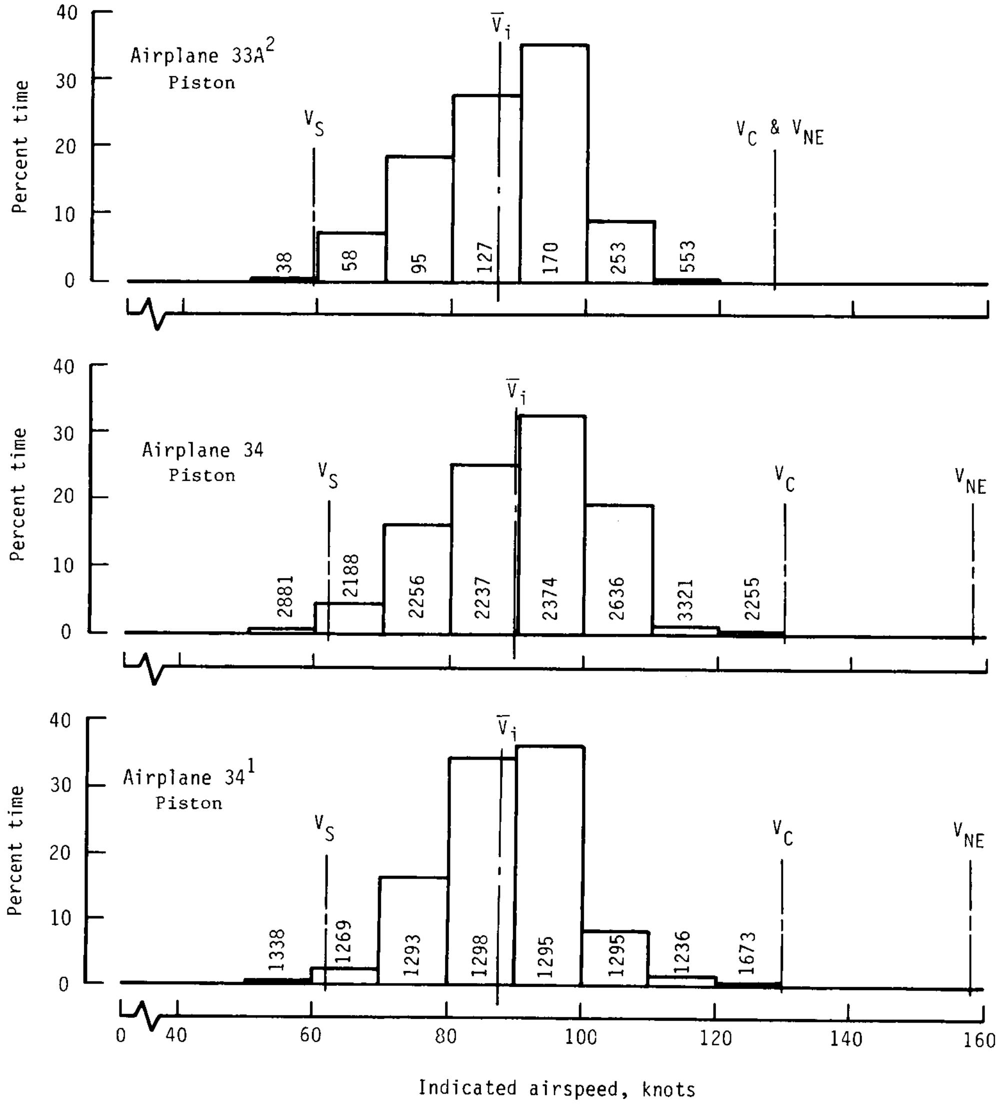

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Figure 6.- Continued.

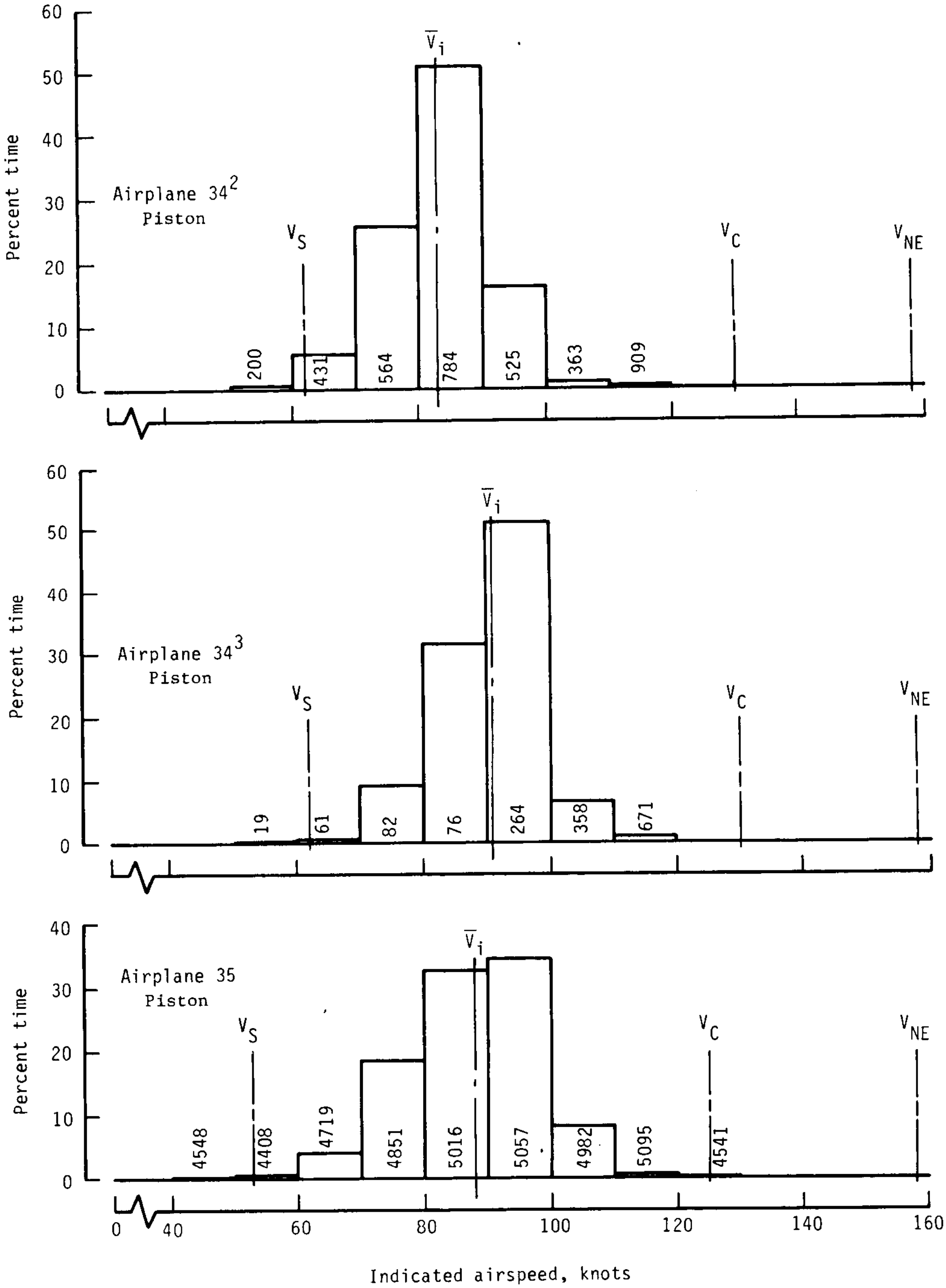

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Figure 6.- Continued.

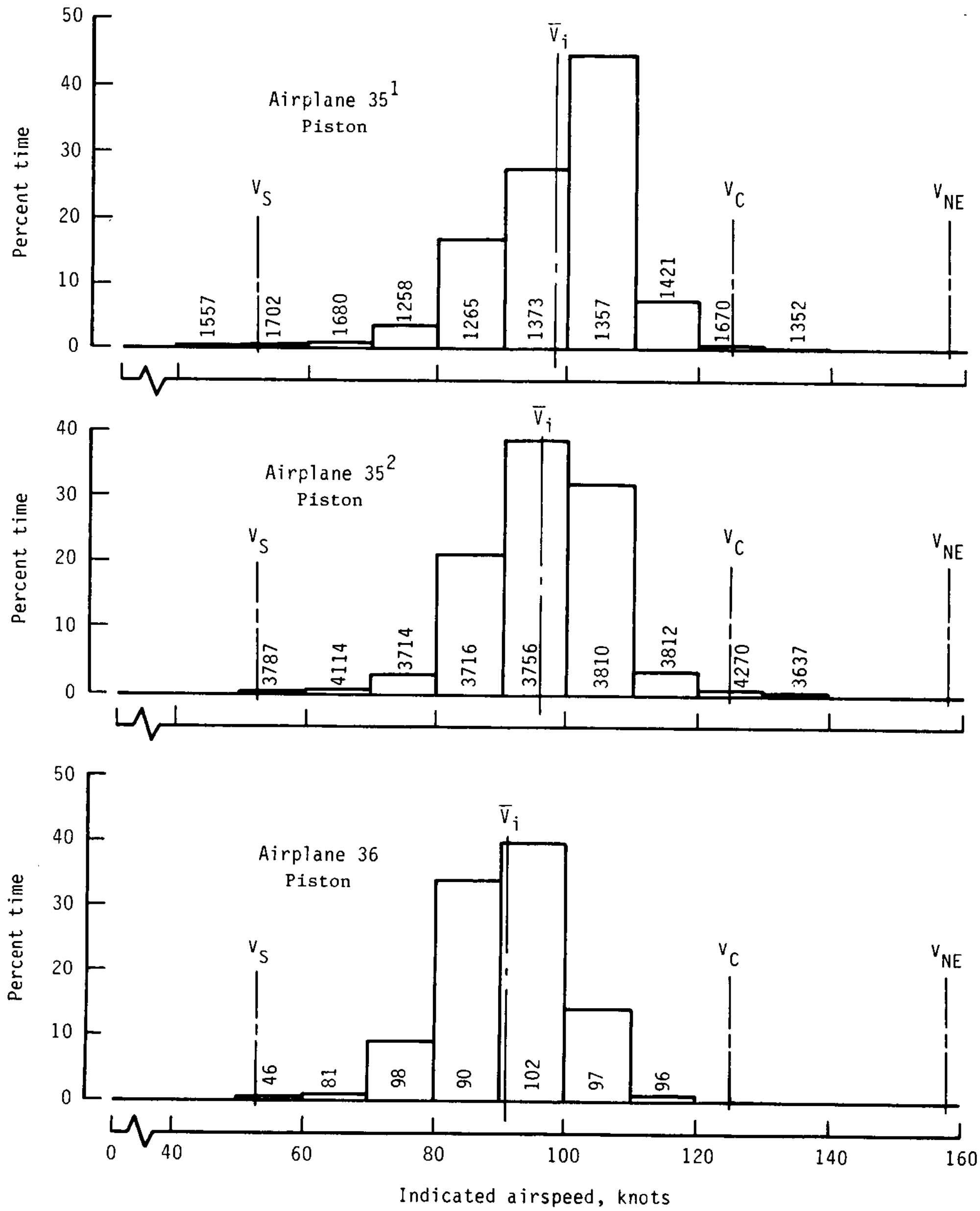

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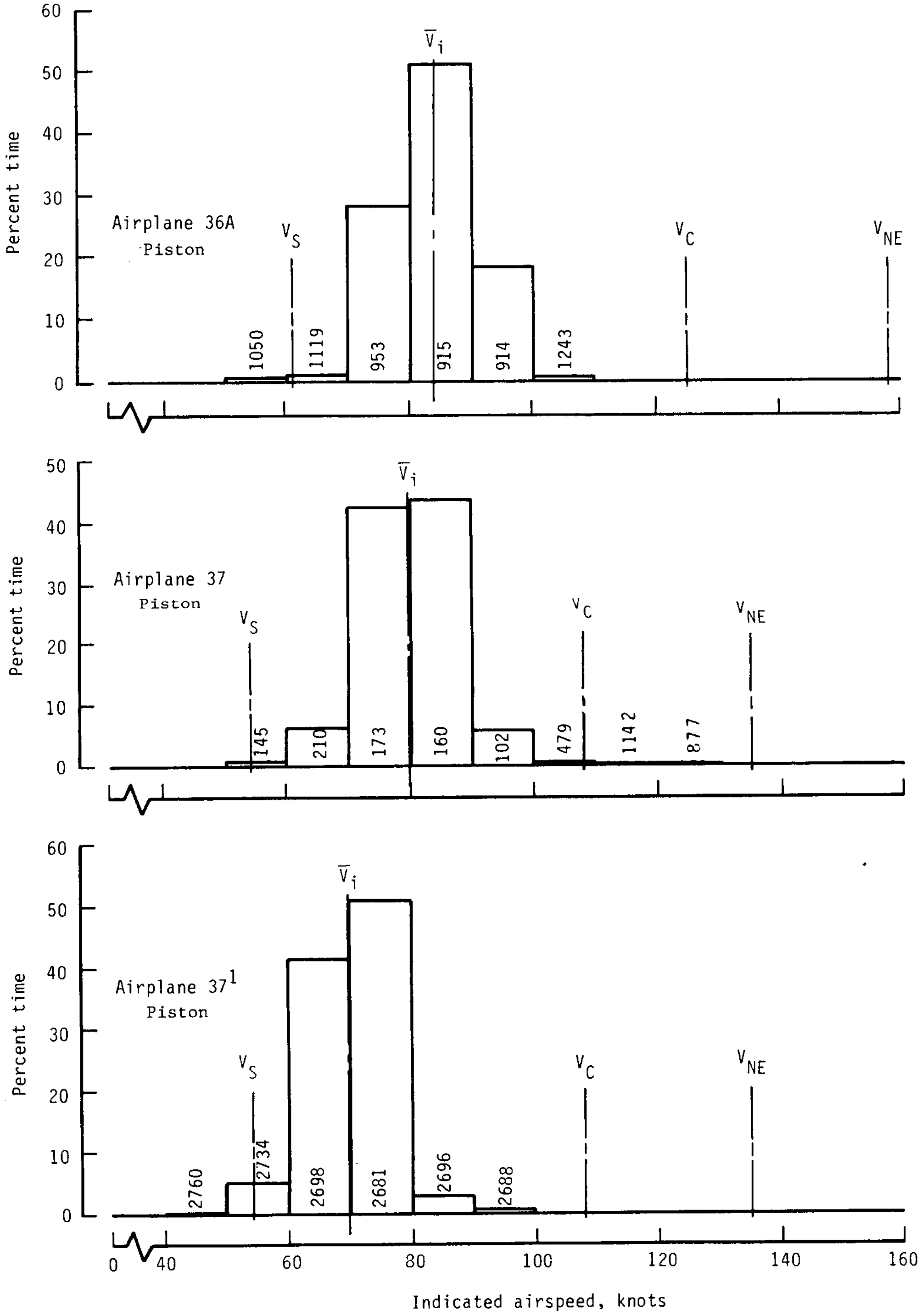
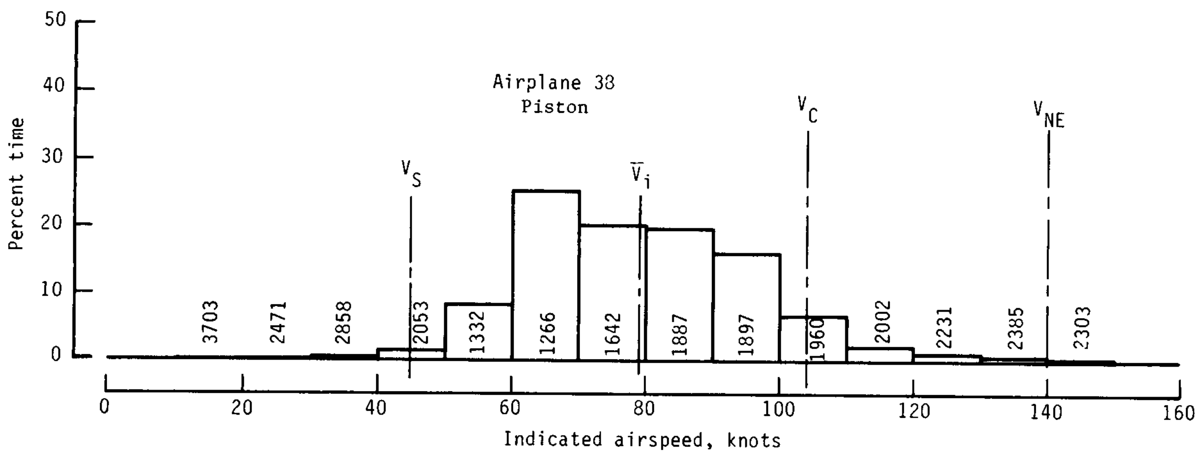
Figure 6.- Continued.



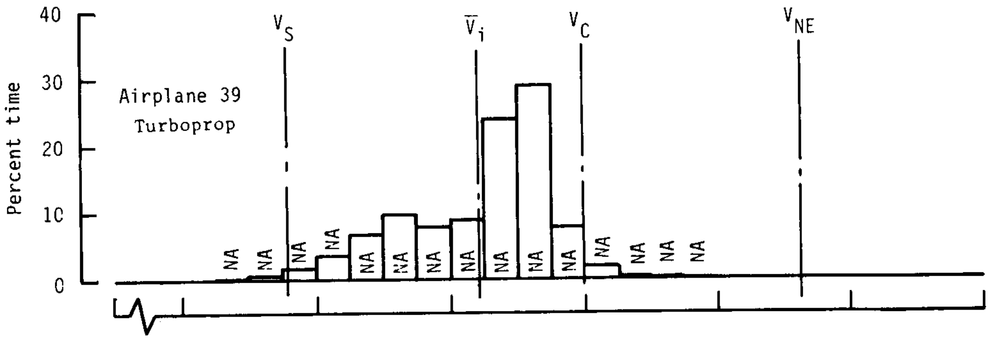
(f) Concluded.

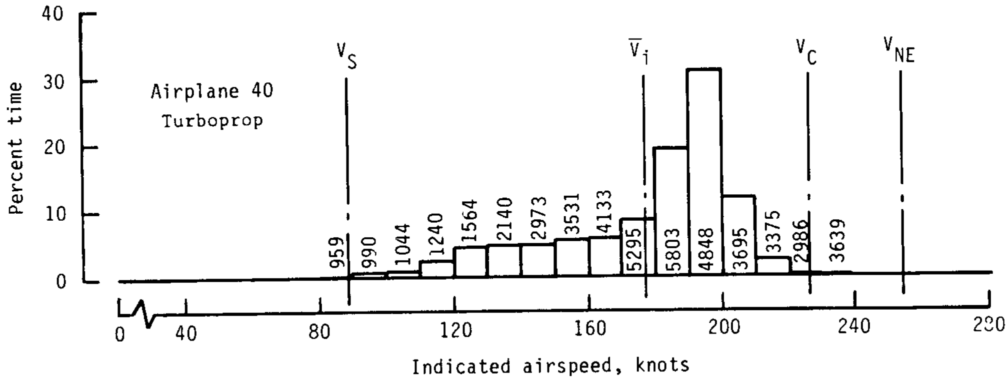
Figure 6.- Continued.



(g) Aerobatic operations.

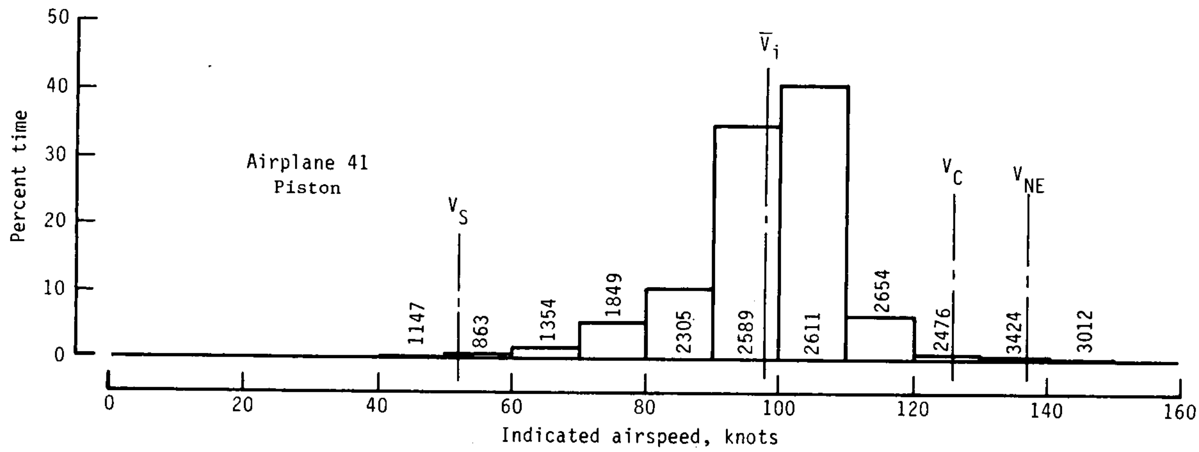
Figure 6.- Continued.





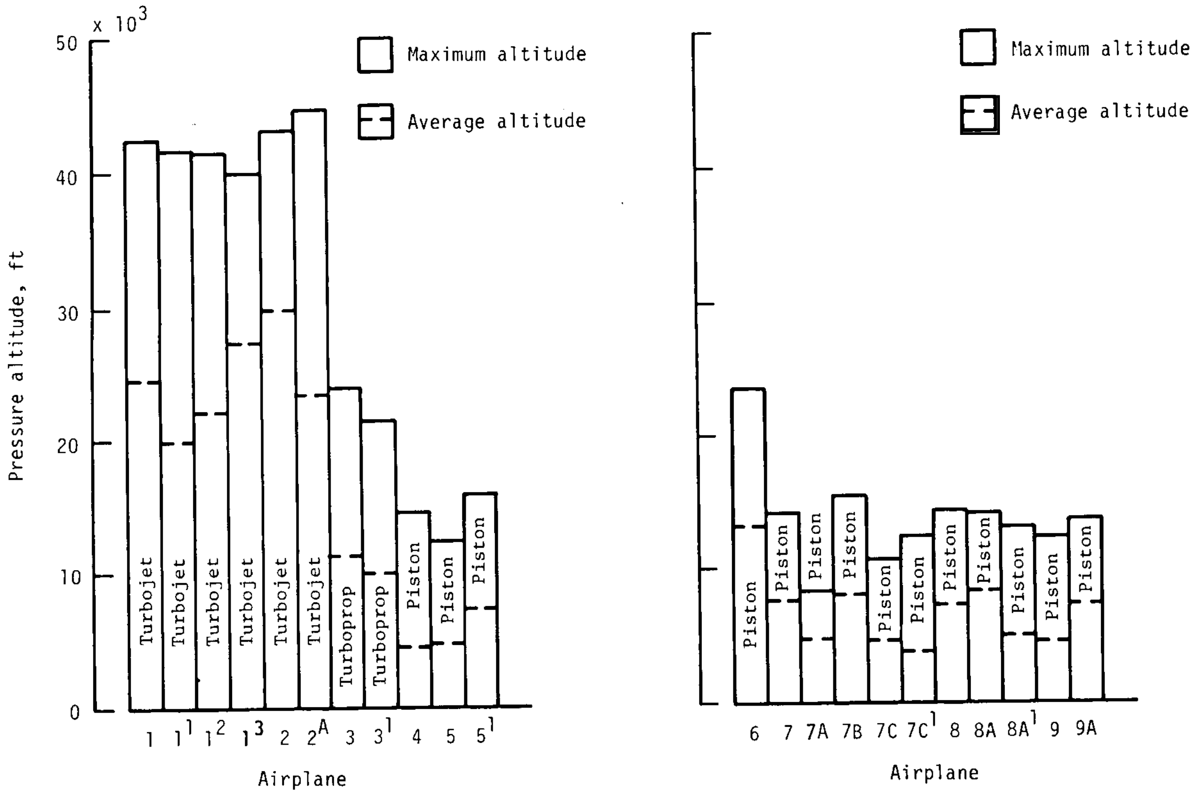
(h) Commuter operations.

Figure 6.- Continued.



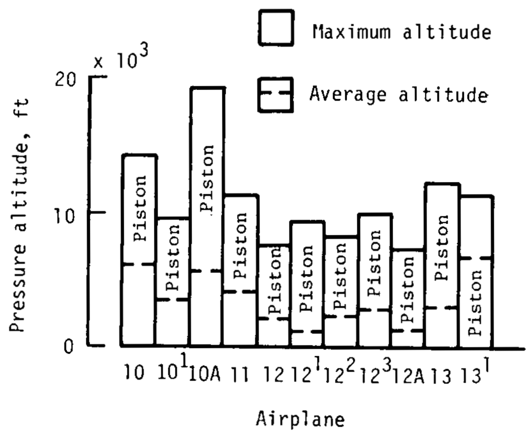
(i) Float operations.

Figure 6.- Concluded.

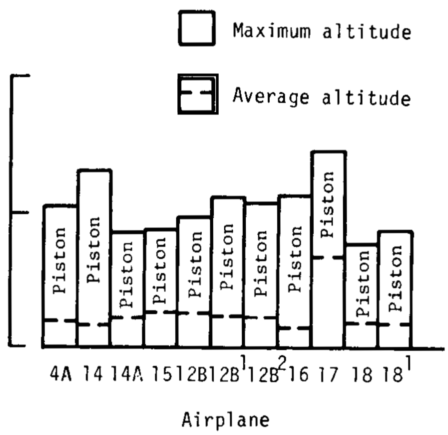


(a) Twin-engine executive operations. (b) Single-engine executive operations.

Figure 7.- Maximum and average altitudes of individual airplanes flown in specified types of operations.

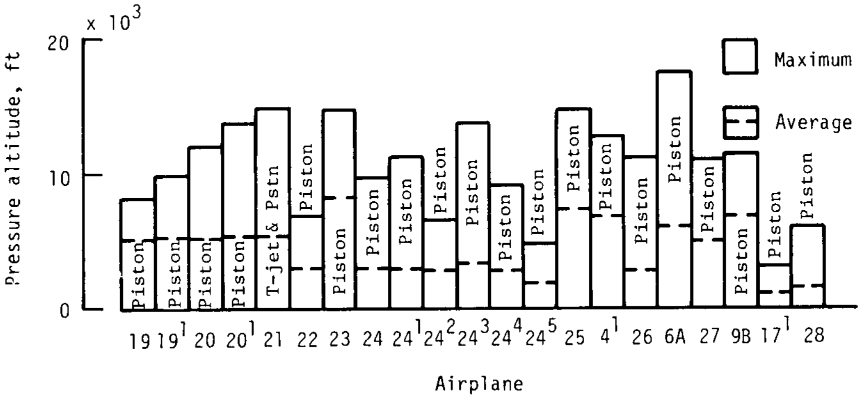


(c) Personal operations.

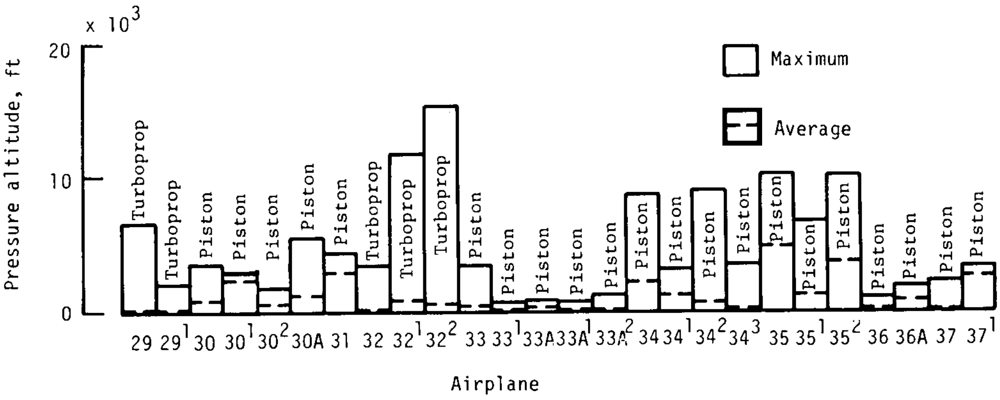


(d) Instructional operations.

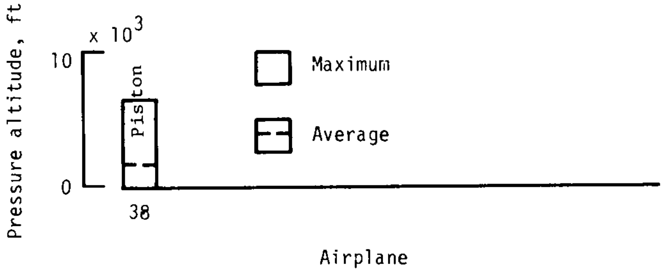
Figure 7.- Continued.



(e) Commercial survey operations.

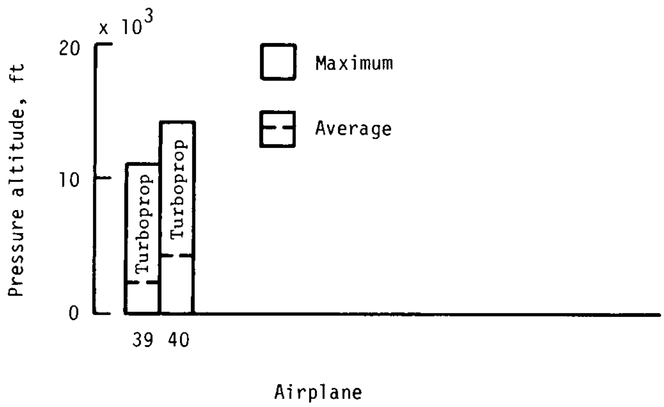


(f) Aerial application operations.

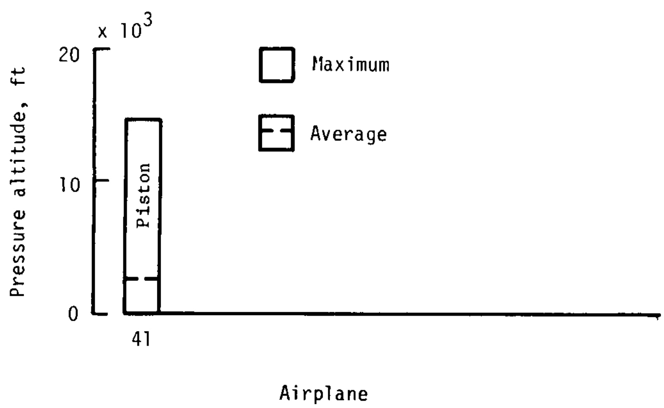


(g) Aerobatic operations.

Figure 7.- Continued.

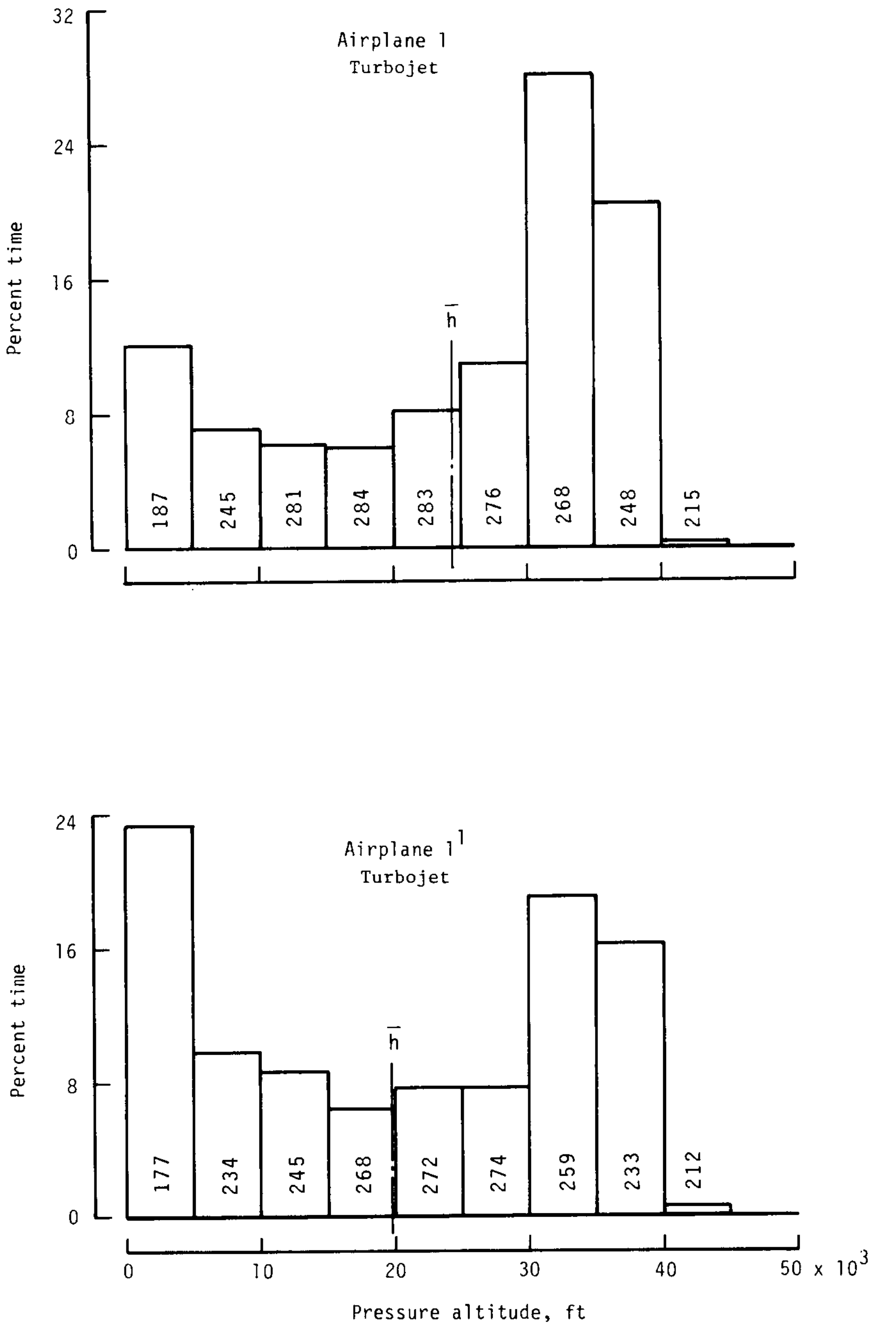


(h) Commuter operations.



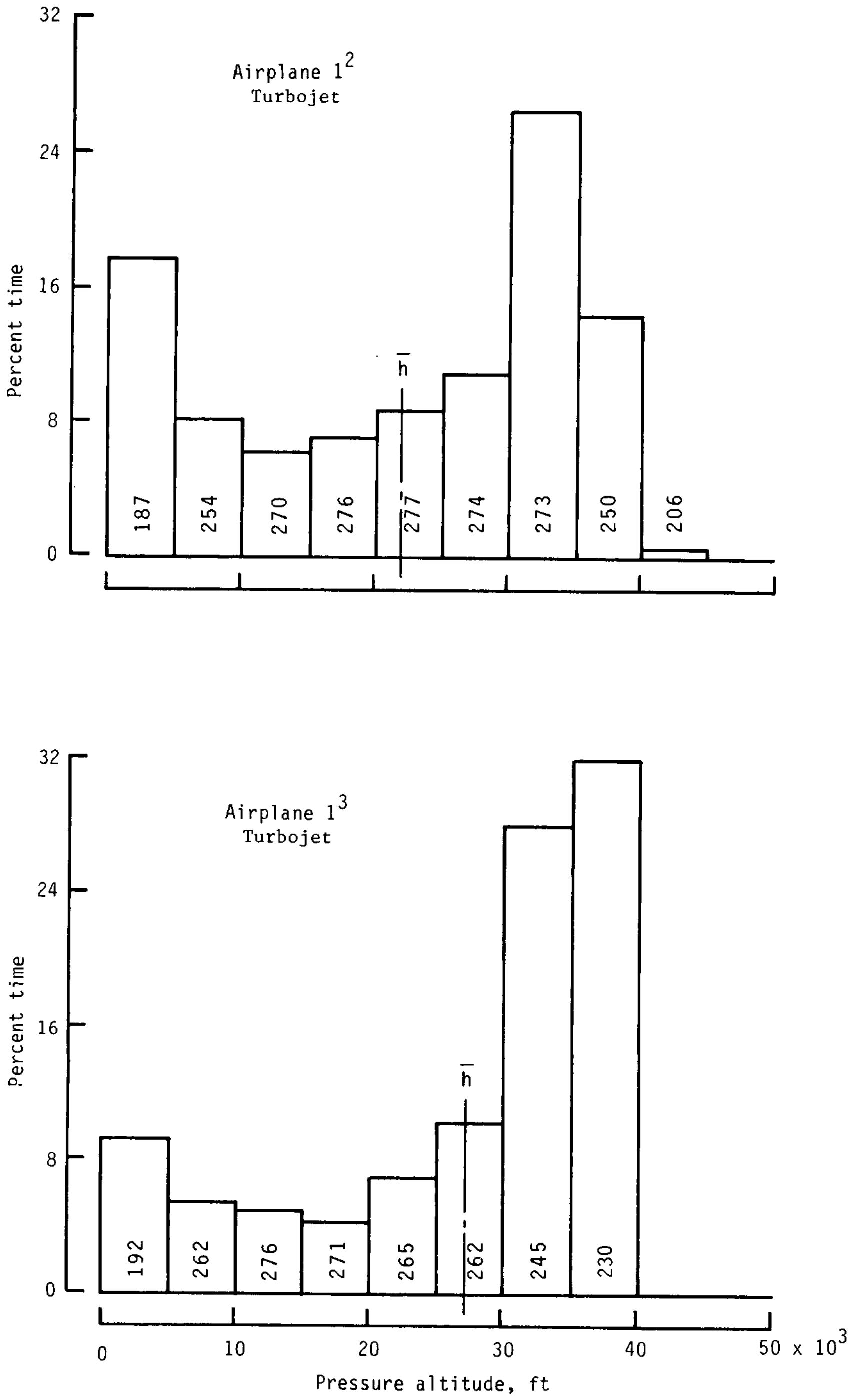
(i) Float operations.

Figure 7.- Concluded.



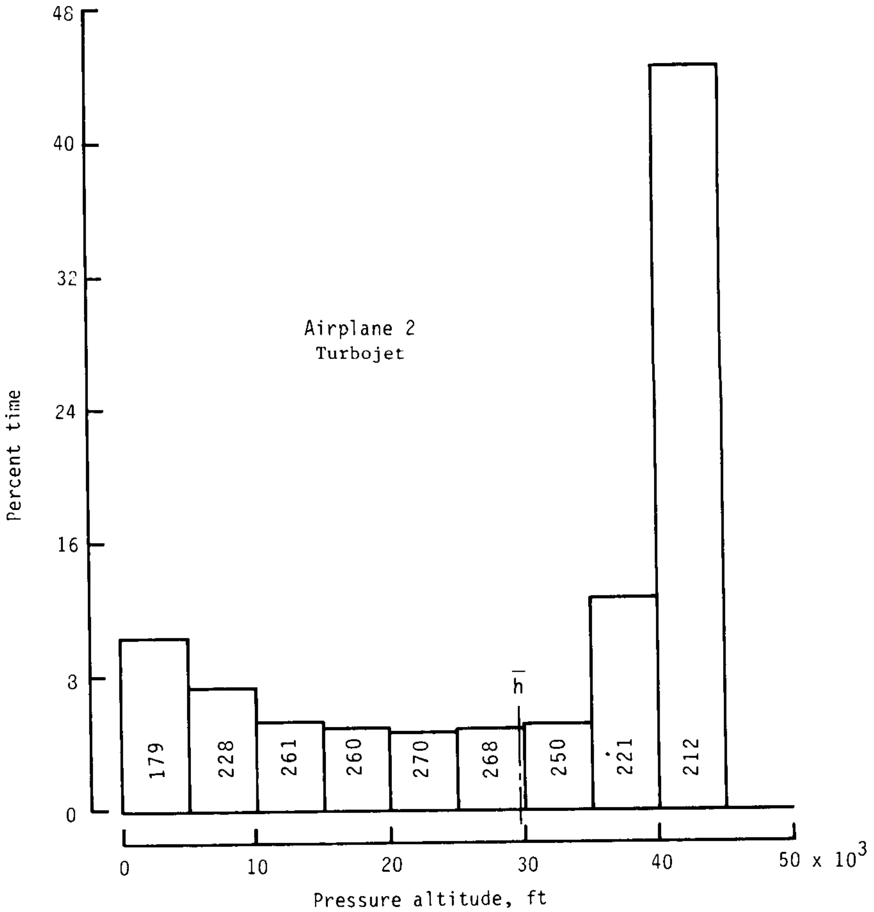
(a) Twin-engine executive operations.

Figure 8.- Percent of time flown in noted altitude intervals by airplanes in specified types of operations. Average indicated airspeeds in the intervals are also shown.



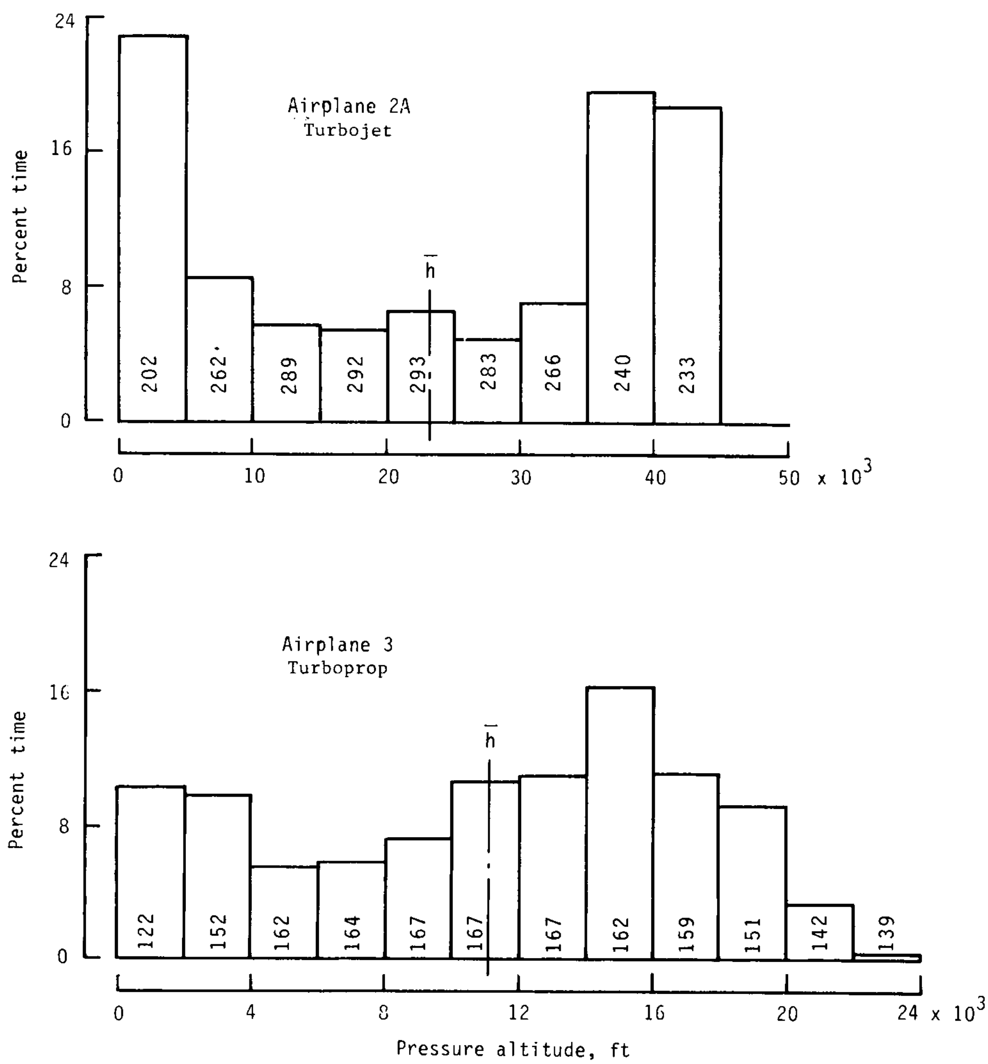
(a) Continued.

Figure 8.- Continued.



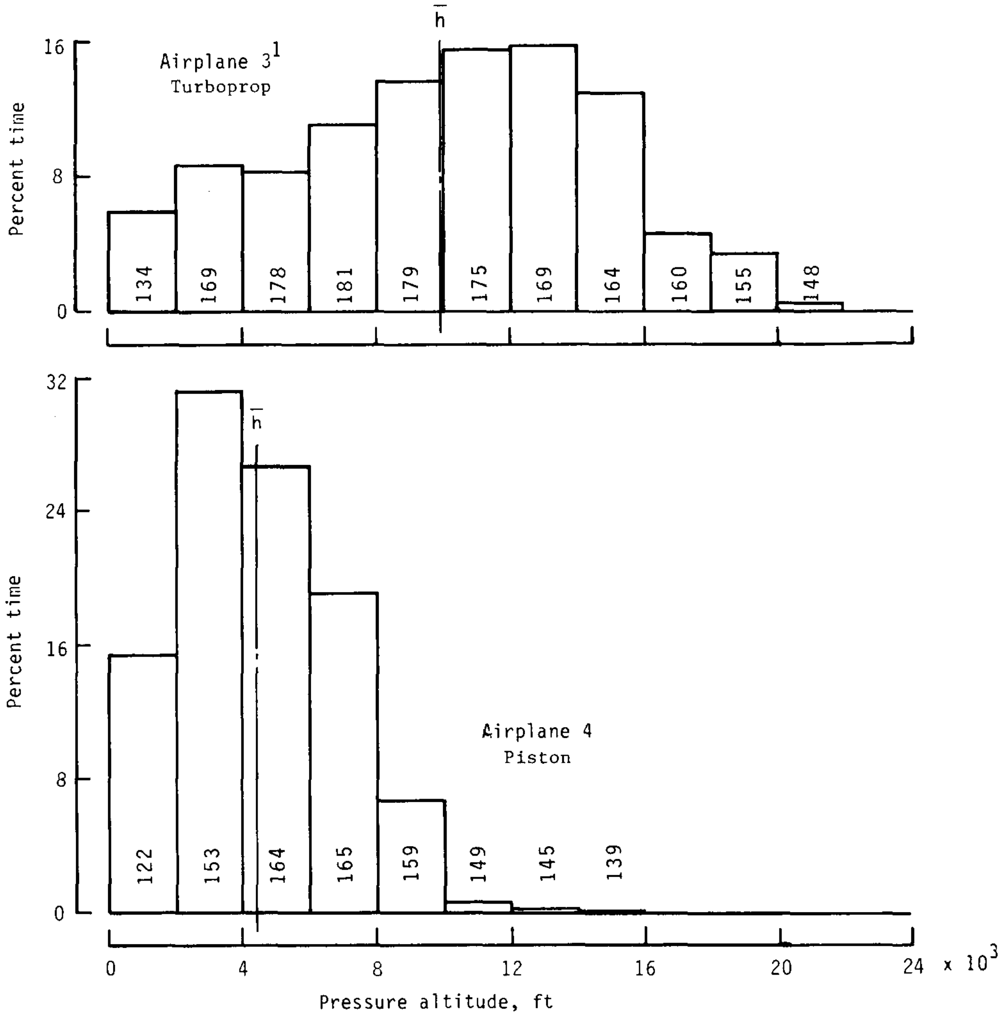
(a) Continued.

Figure 8.- Continued.



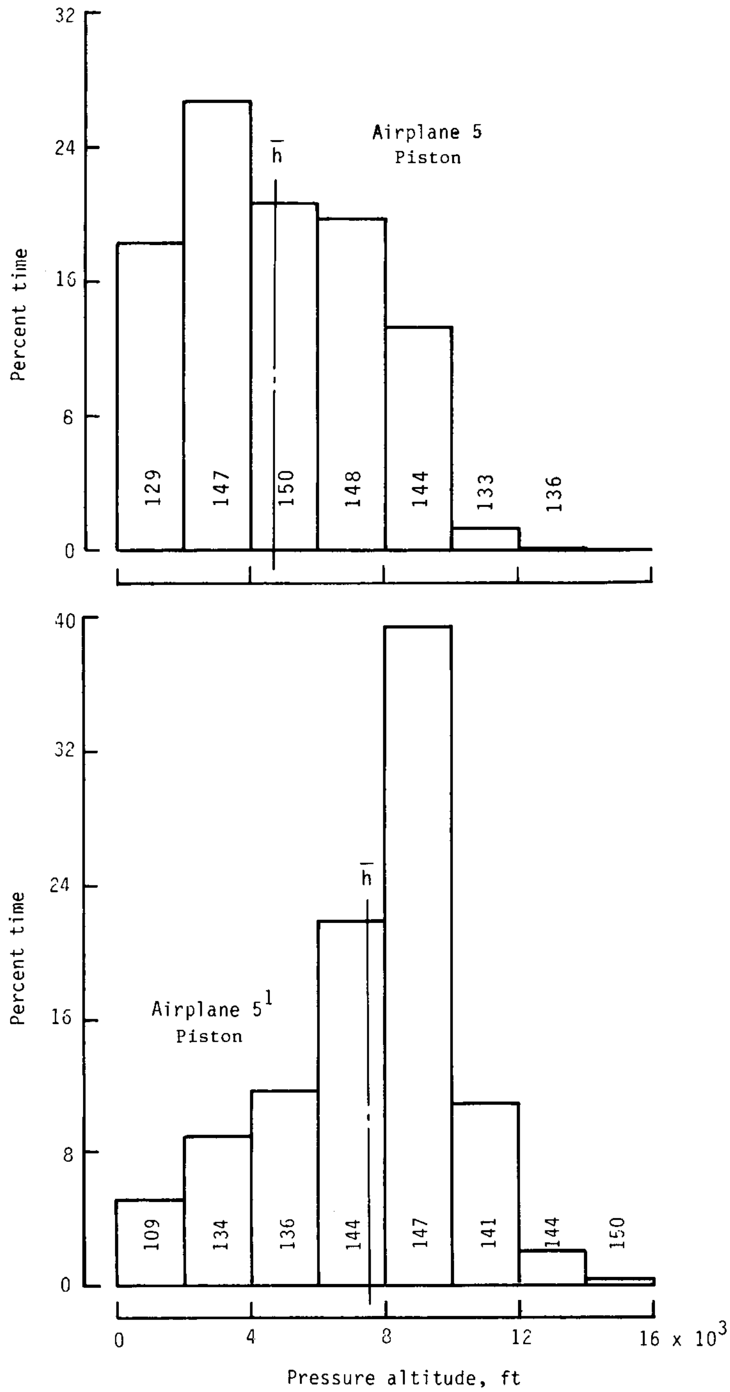
(a) Continued.

Figure 8.- Continued.



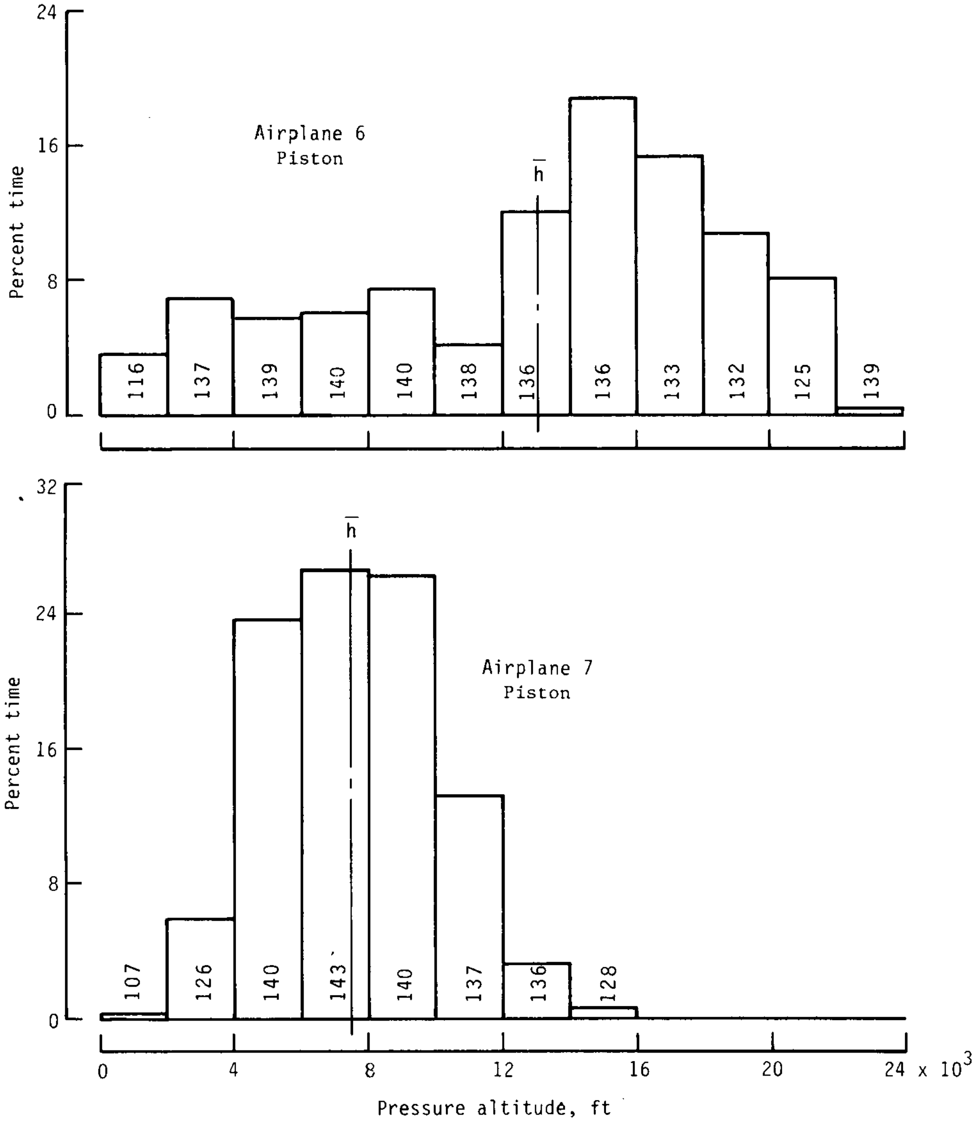
(a) Continued.

Figure 8.- Continued.



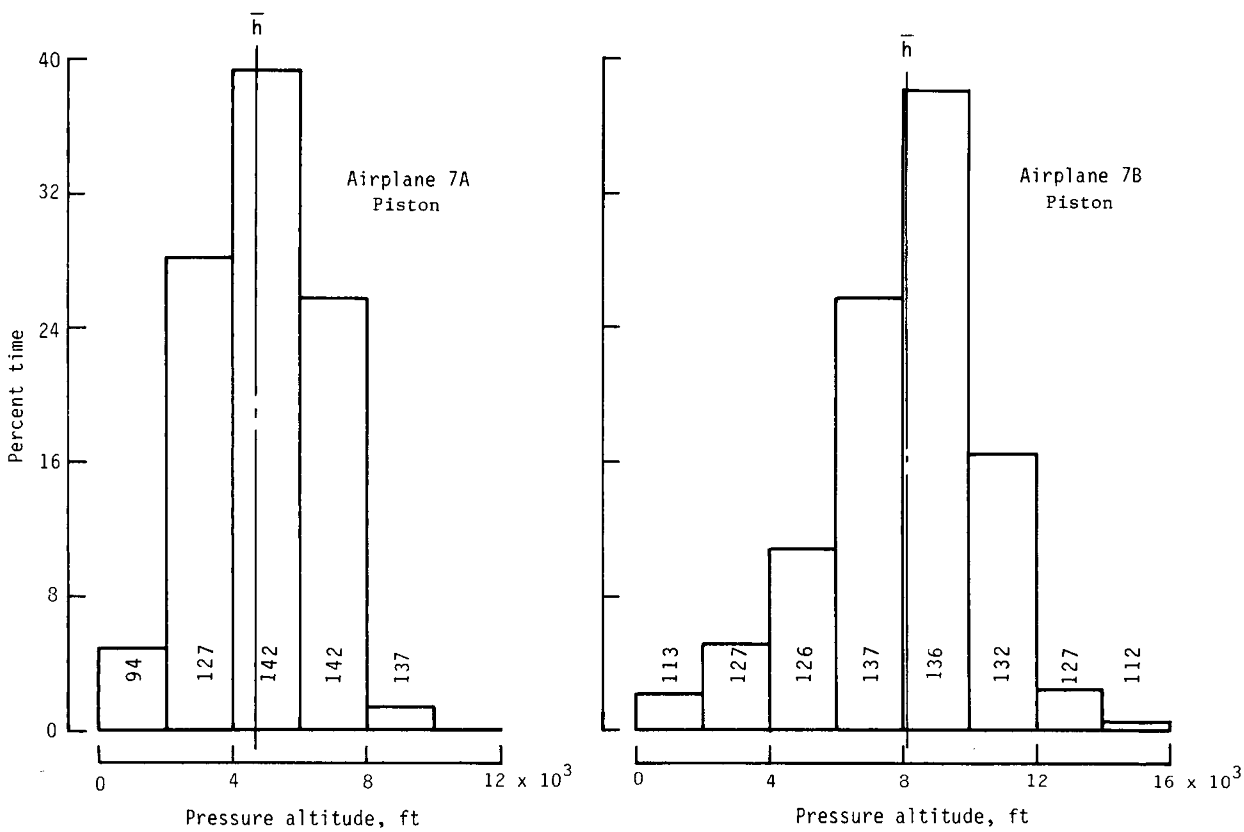
(a) Concluded.

Figure 8.- Continued.



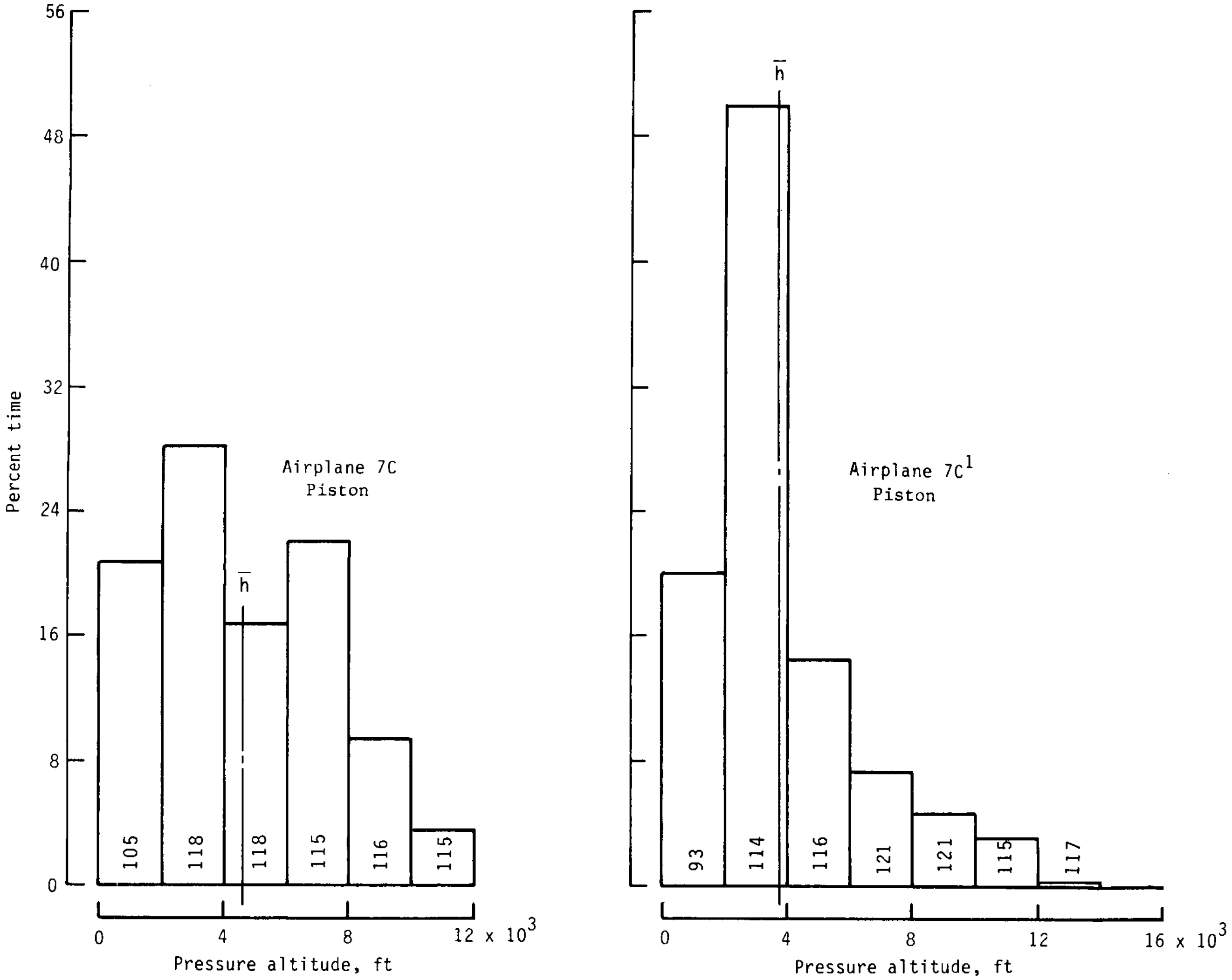
(b) Single-engine executive operations.

Figure 8.- Continued.



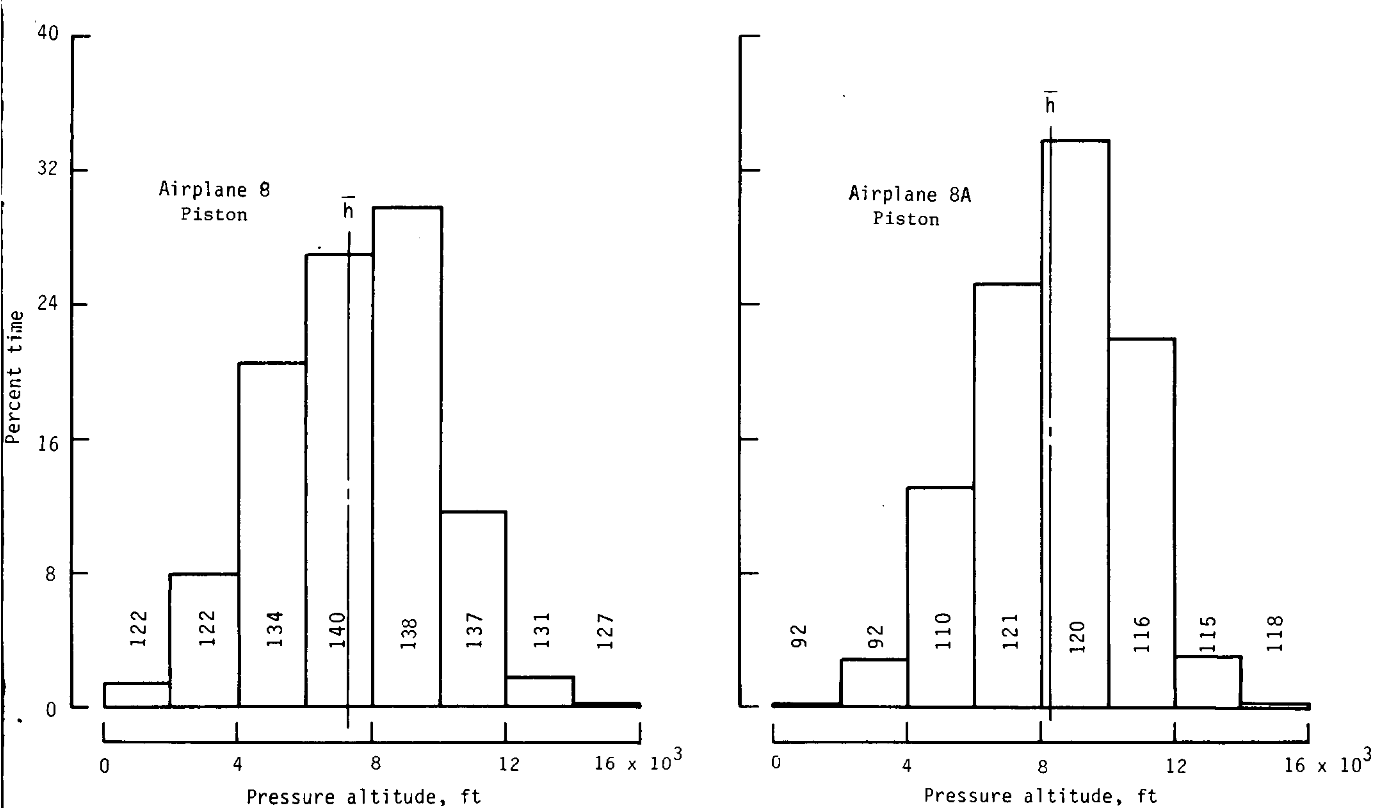
(b) Continued.

Figure 8.- Continued.



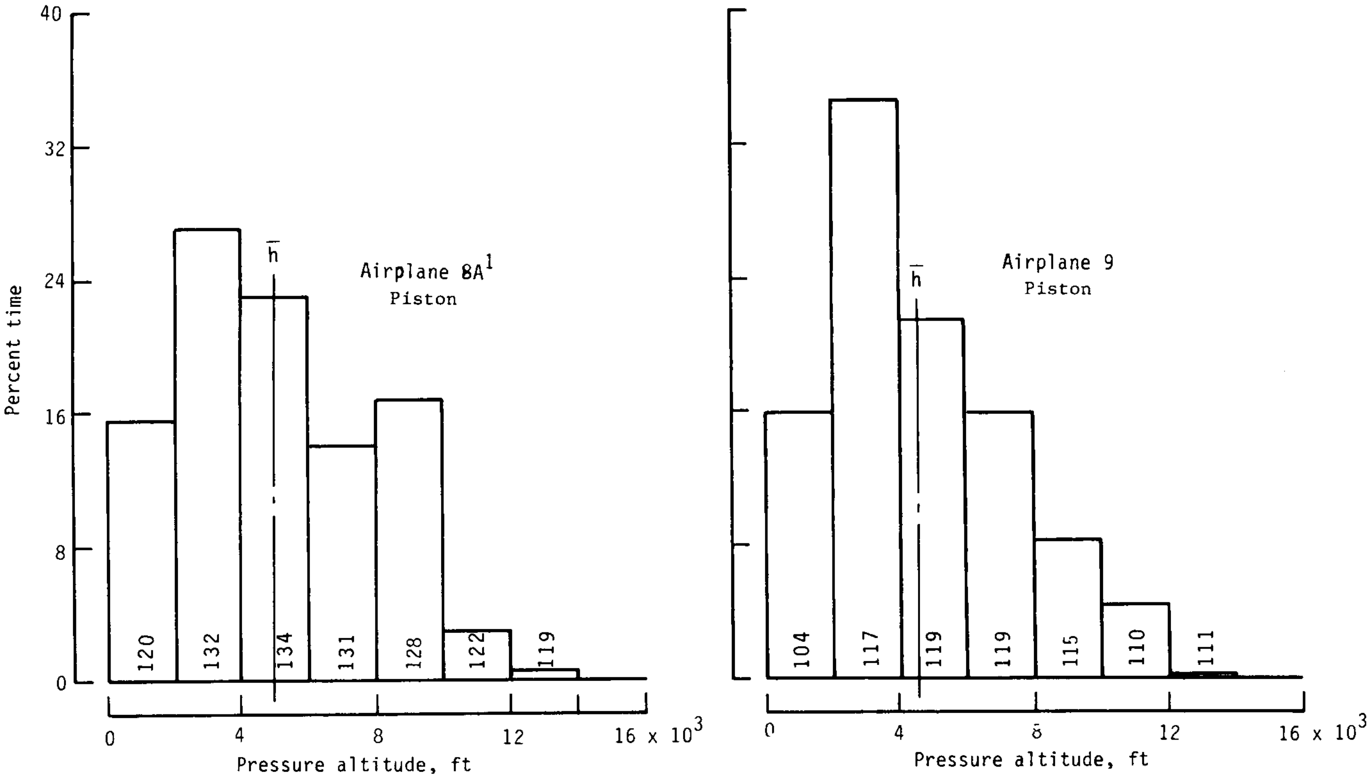
(b) Continued.

Figure 8.- Continued.



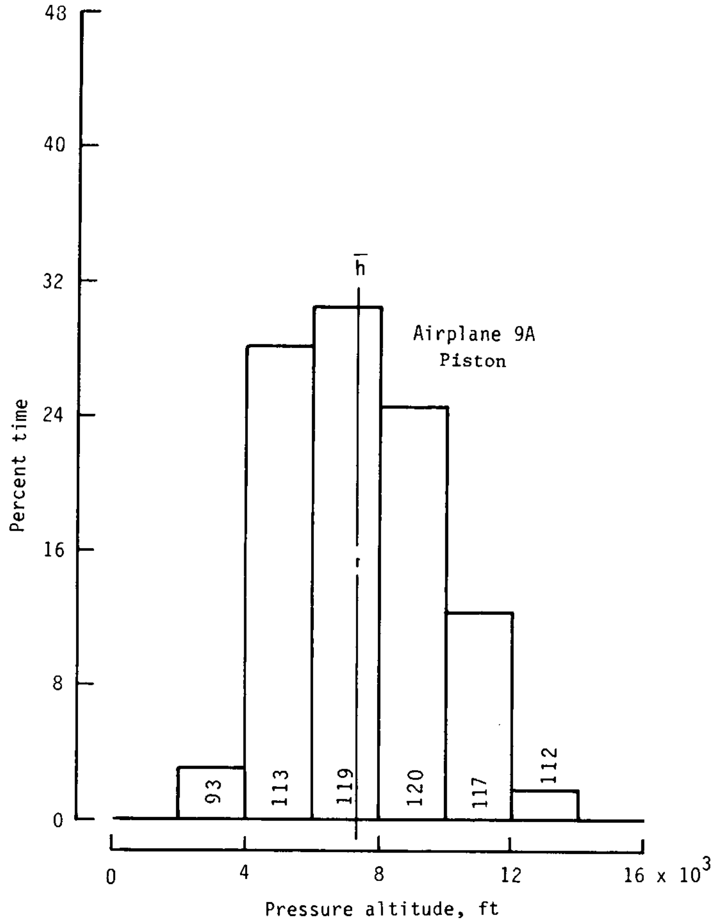
(b) Continued.

Figure 8.- Continued.



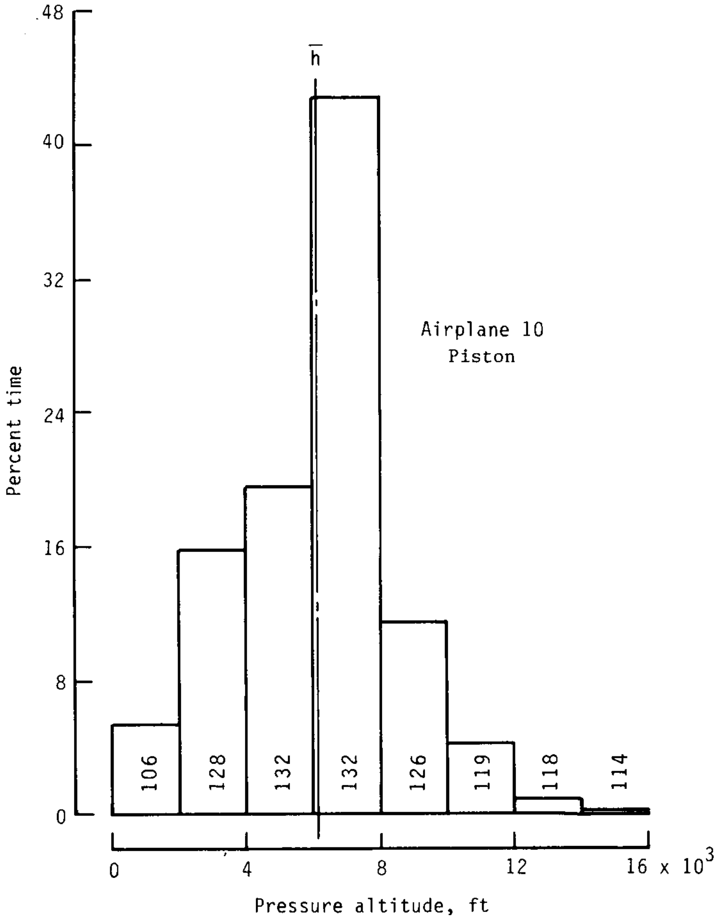
(b) Continued.

Figure 8.- Continued.



(b) Concluded.

Figure 8.- Continued.



(c) Personal operations.

Figure 8.- Continued.

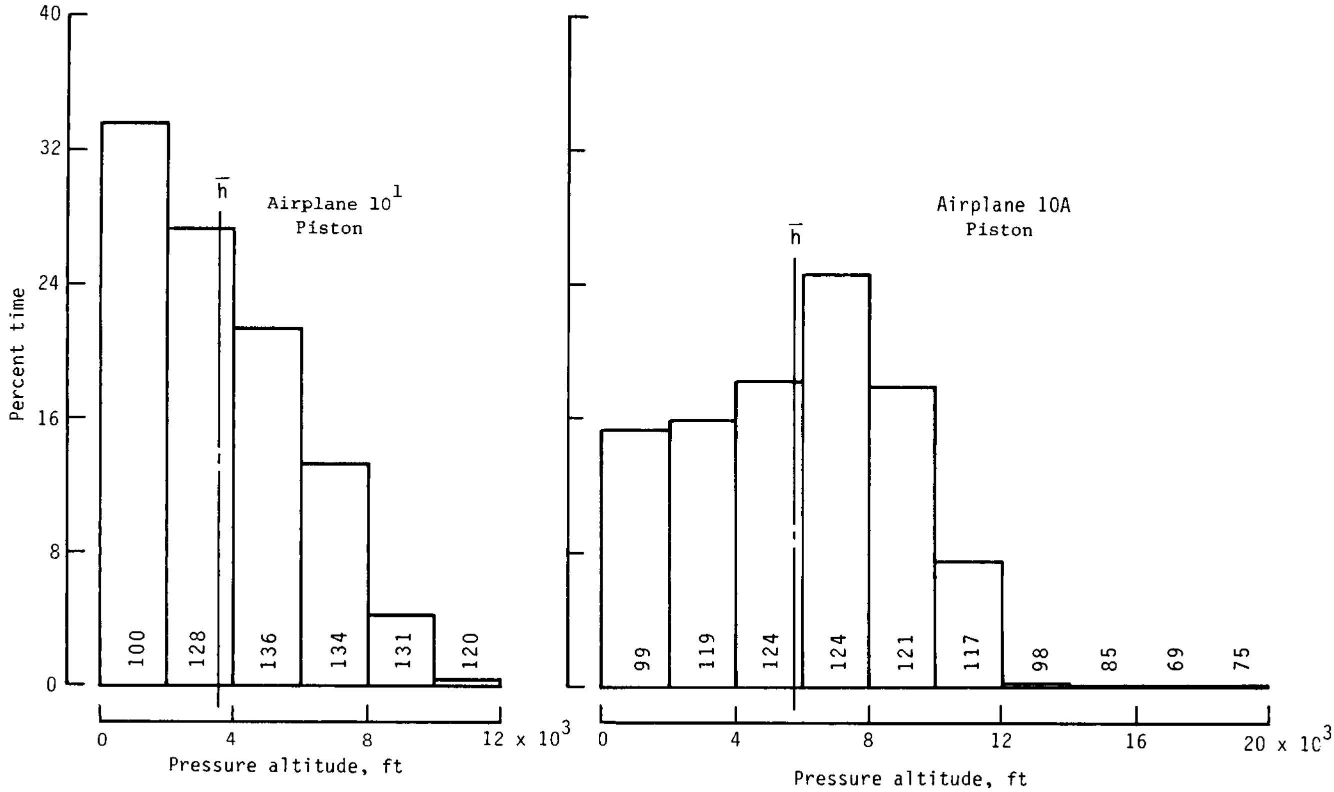


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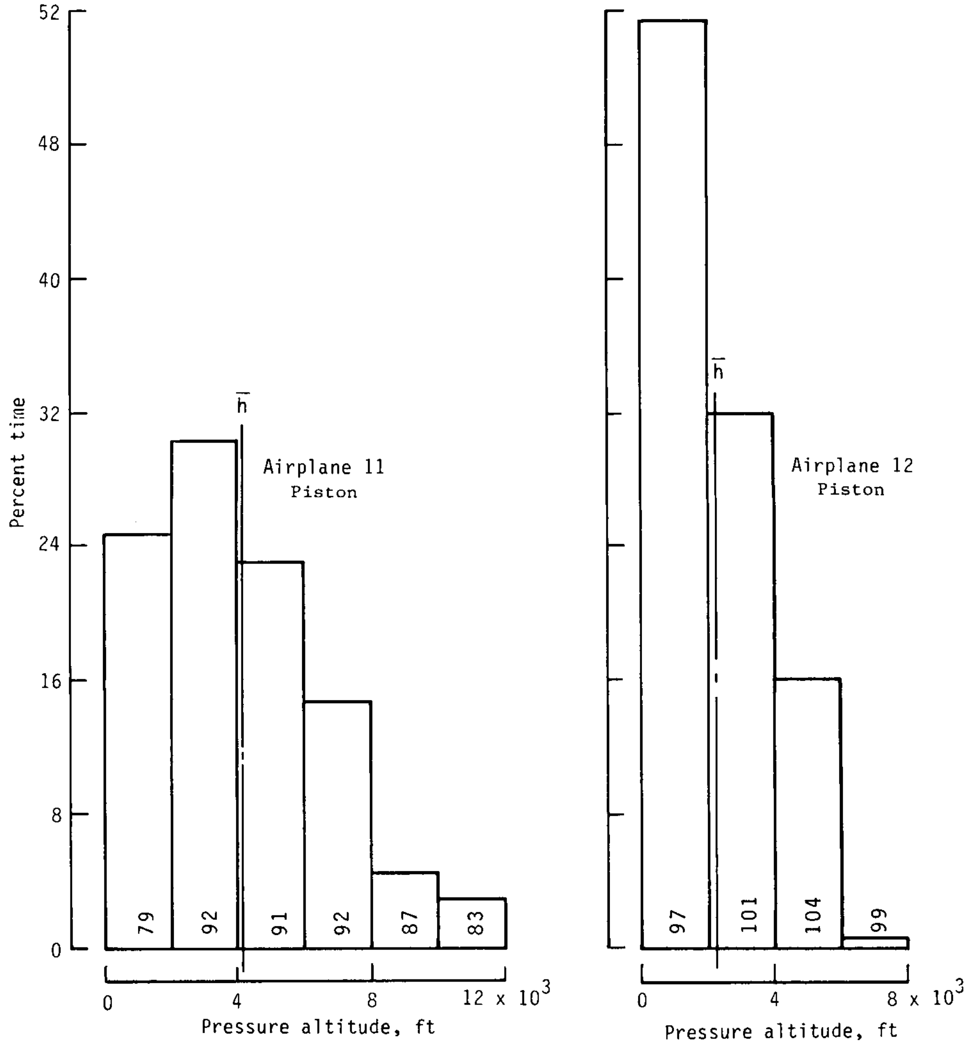
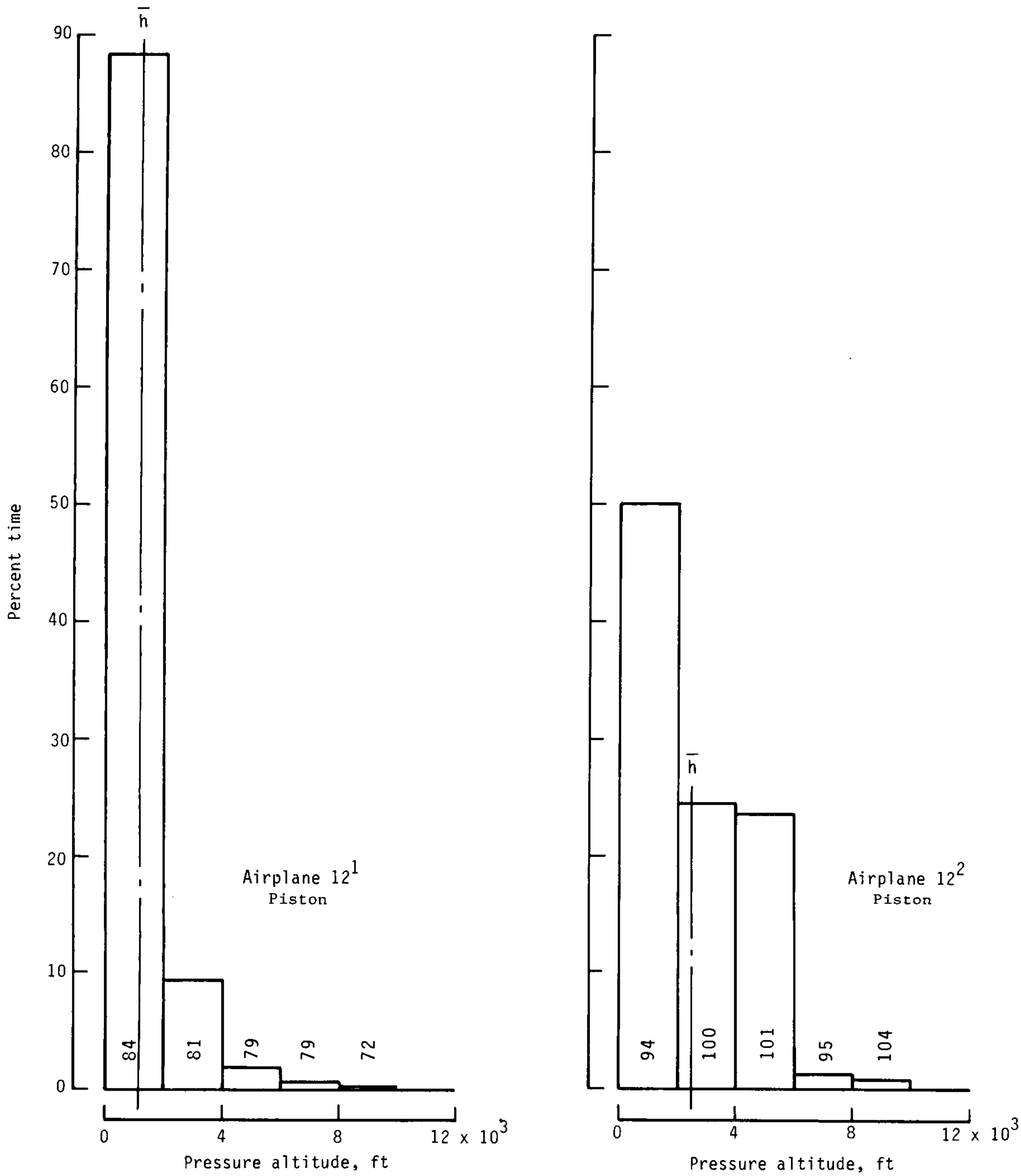
Figure 8.- Continued.



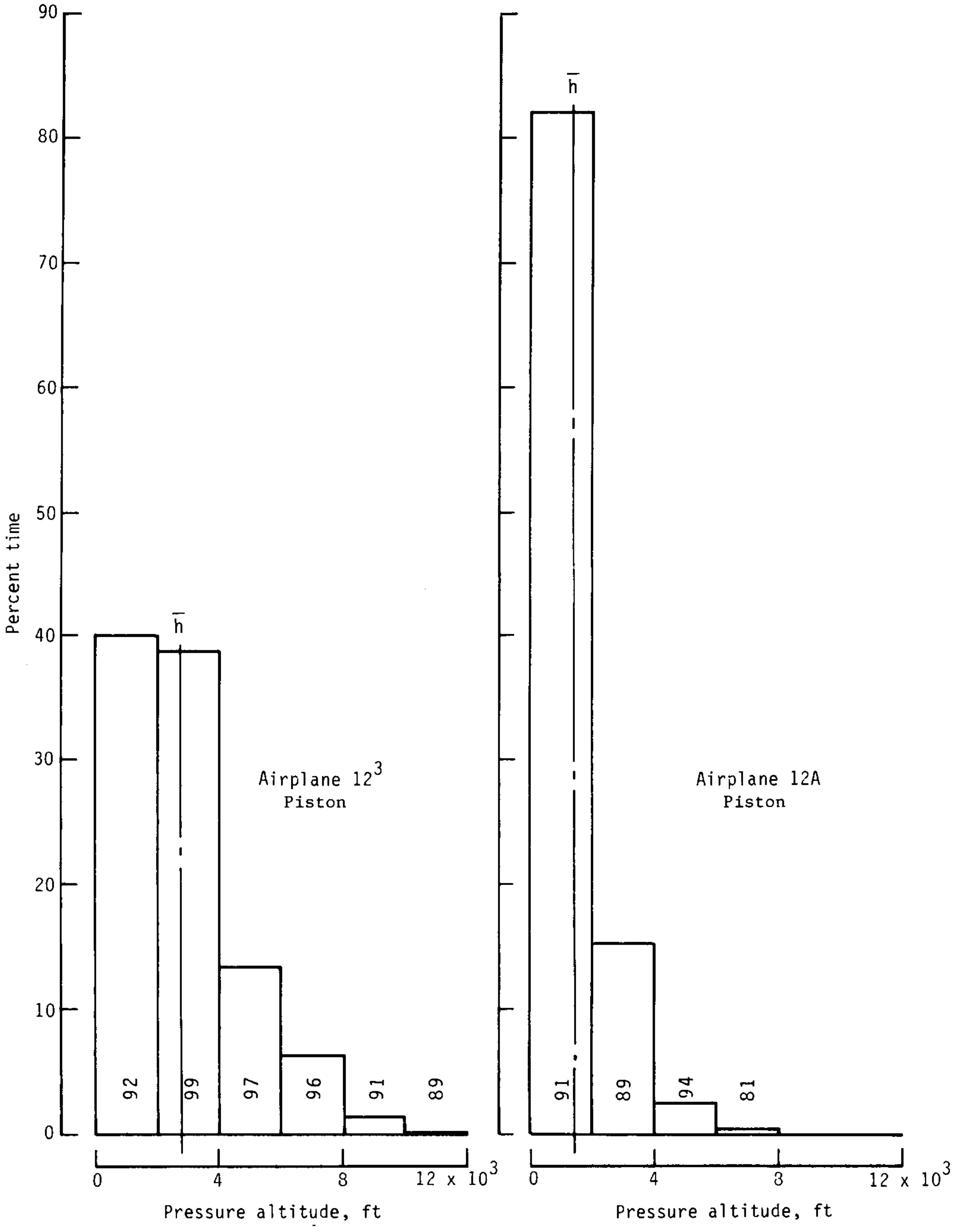
(c) Continued.

Figure 8.- Continued.



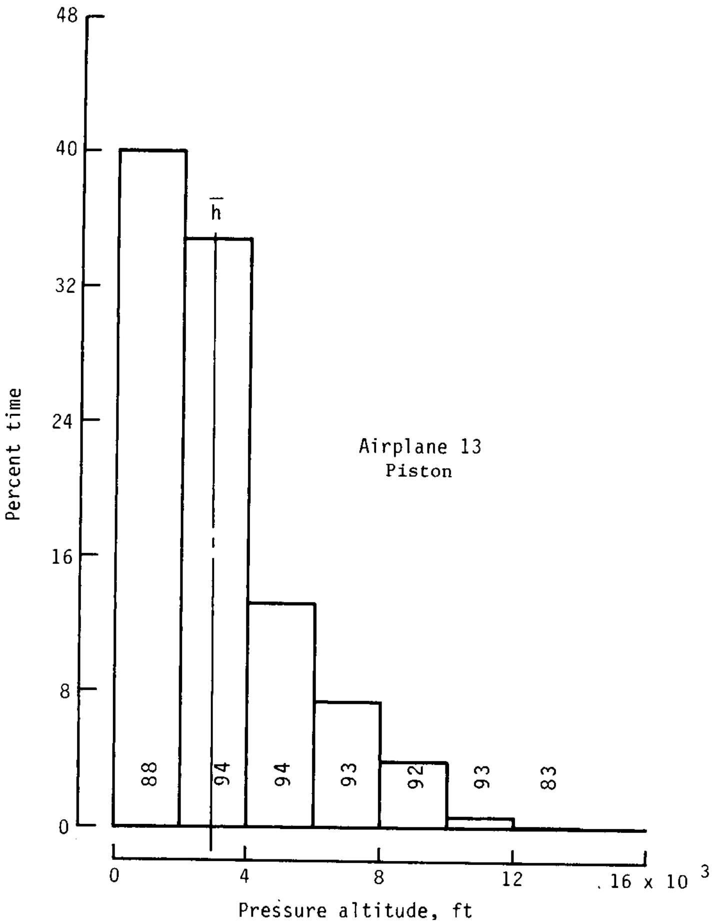
(c) Continued.

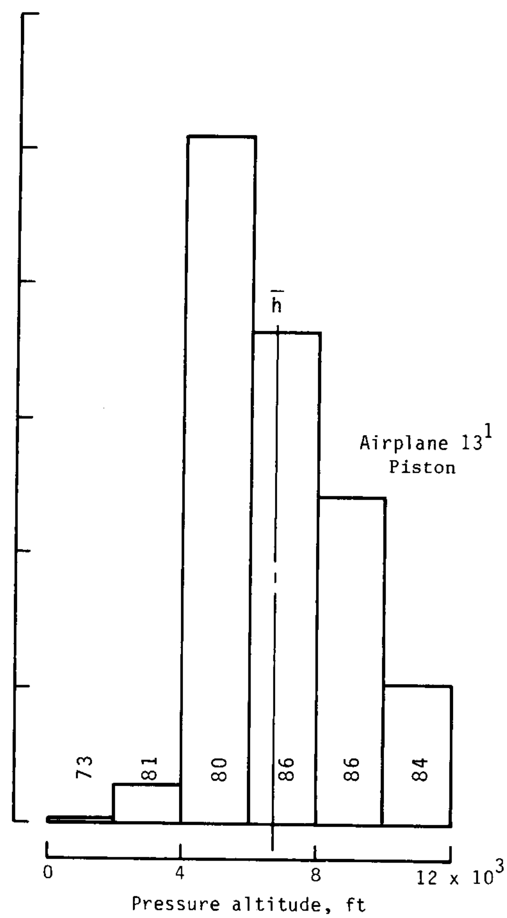
Figure 8.- Continued.



(c) Continued.

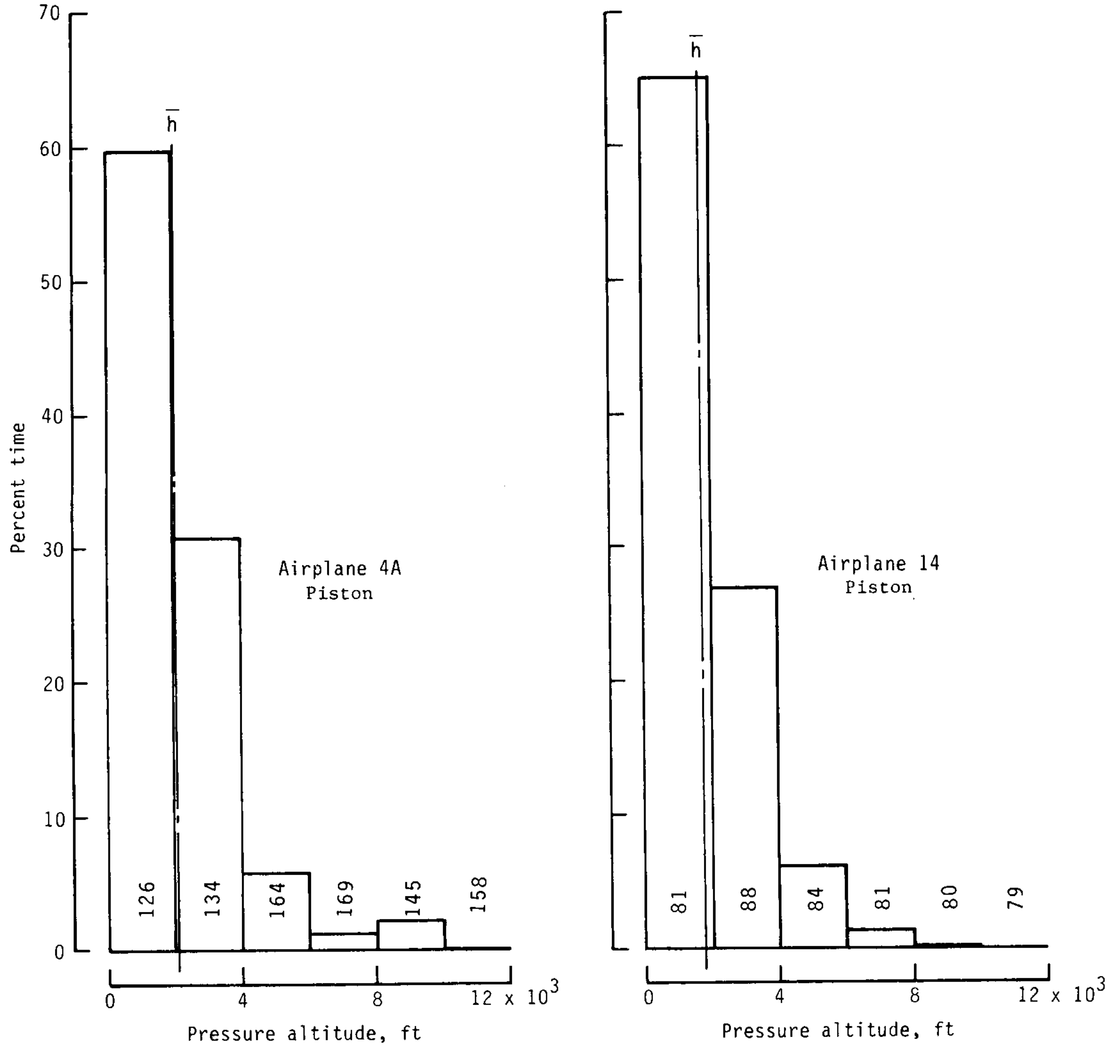
Figure 8.- Continued.





(c) Concluded.

Figure 8.- Continued.



(d) Instructional operations.

Figure 8.- Continued.

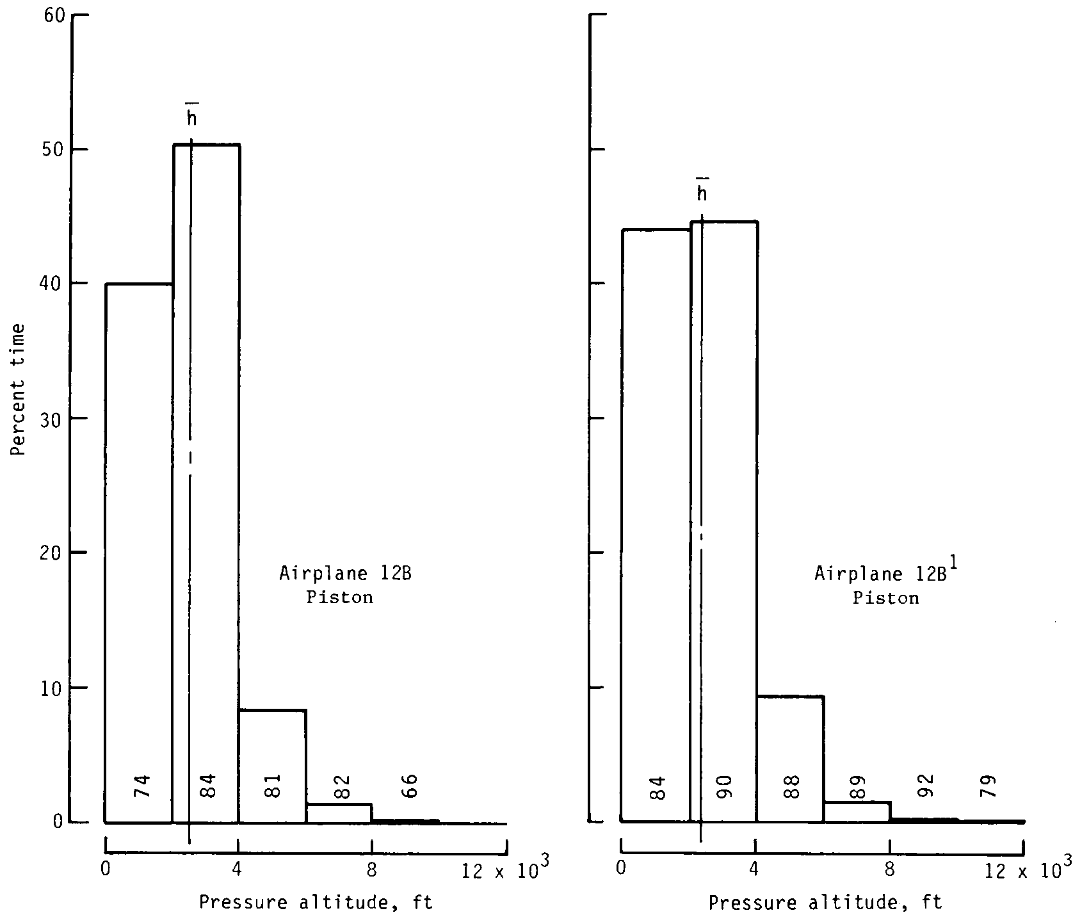


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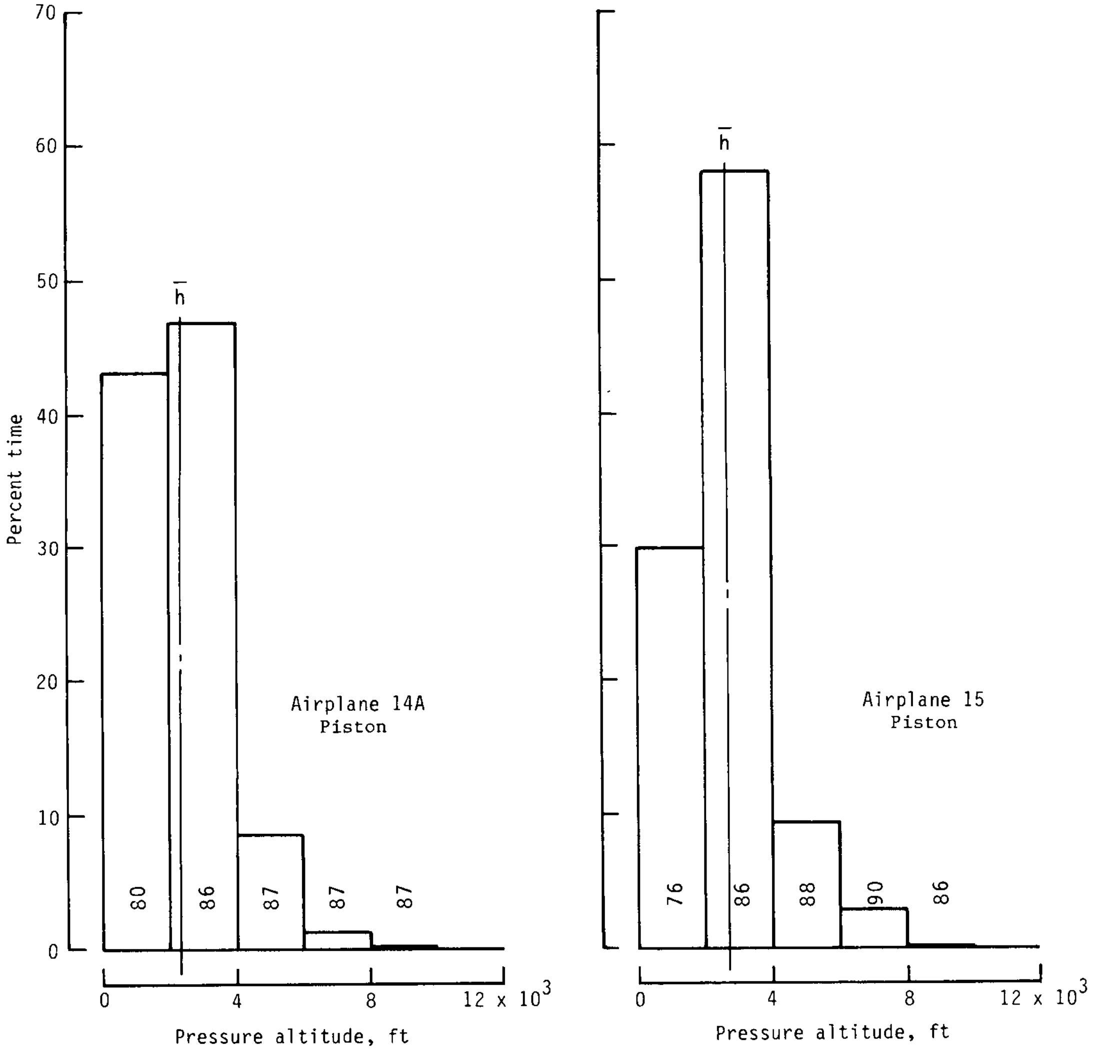
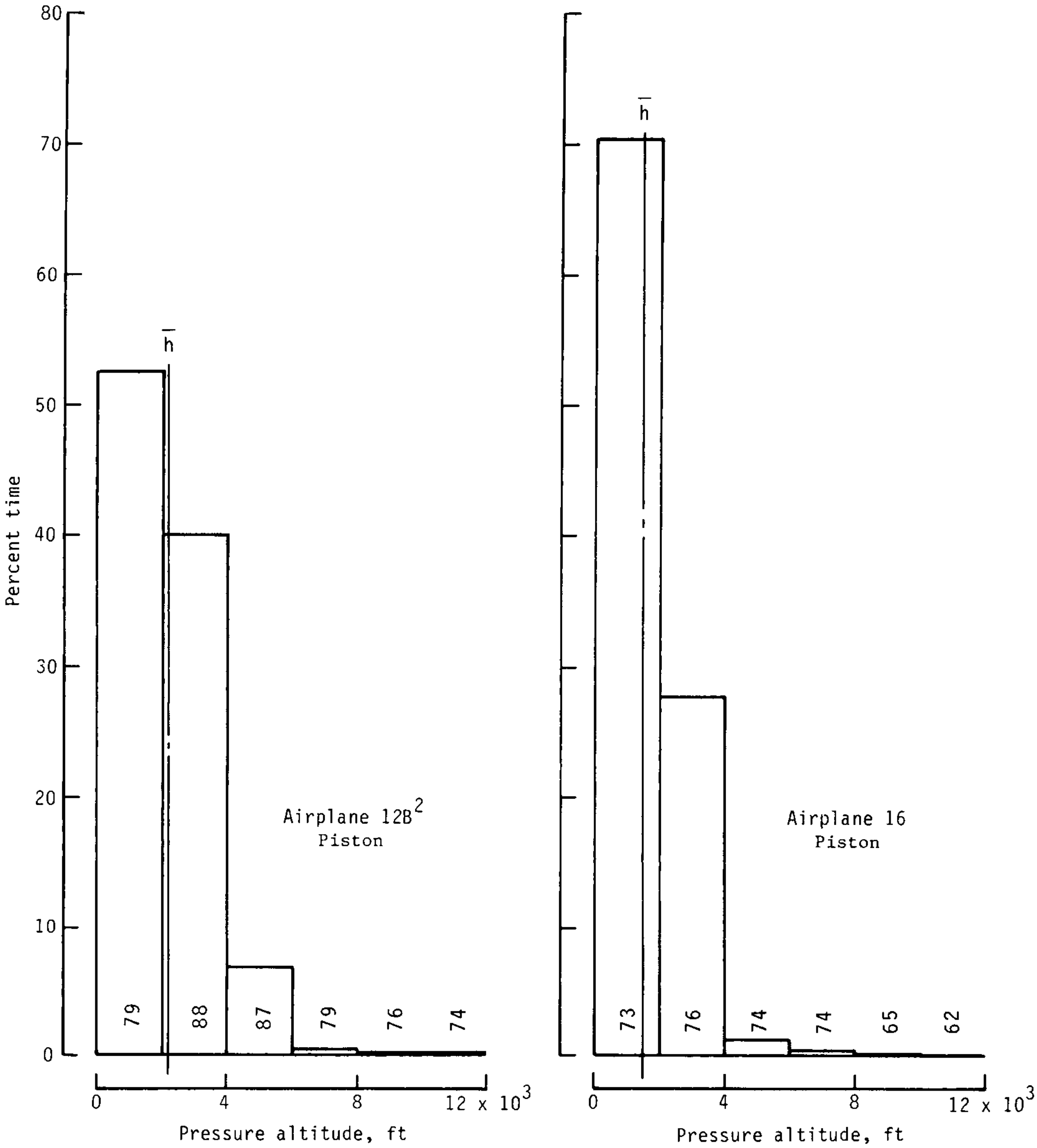
Figure 8.- Continued.



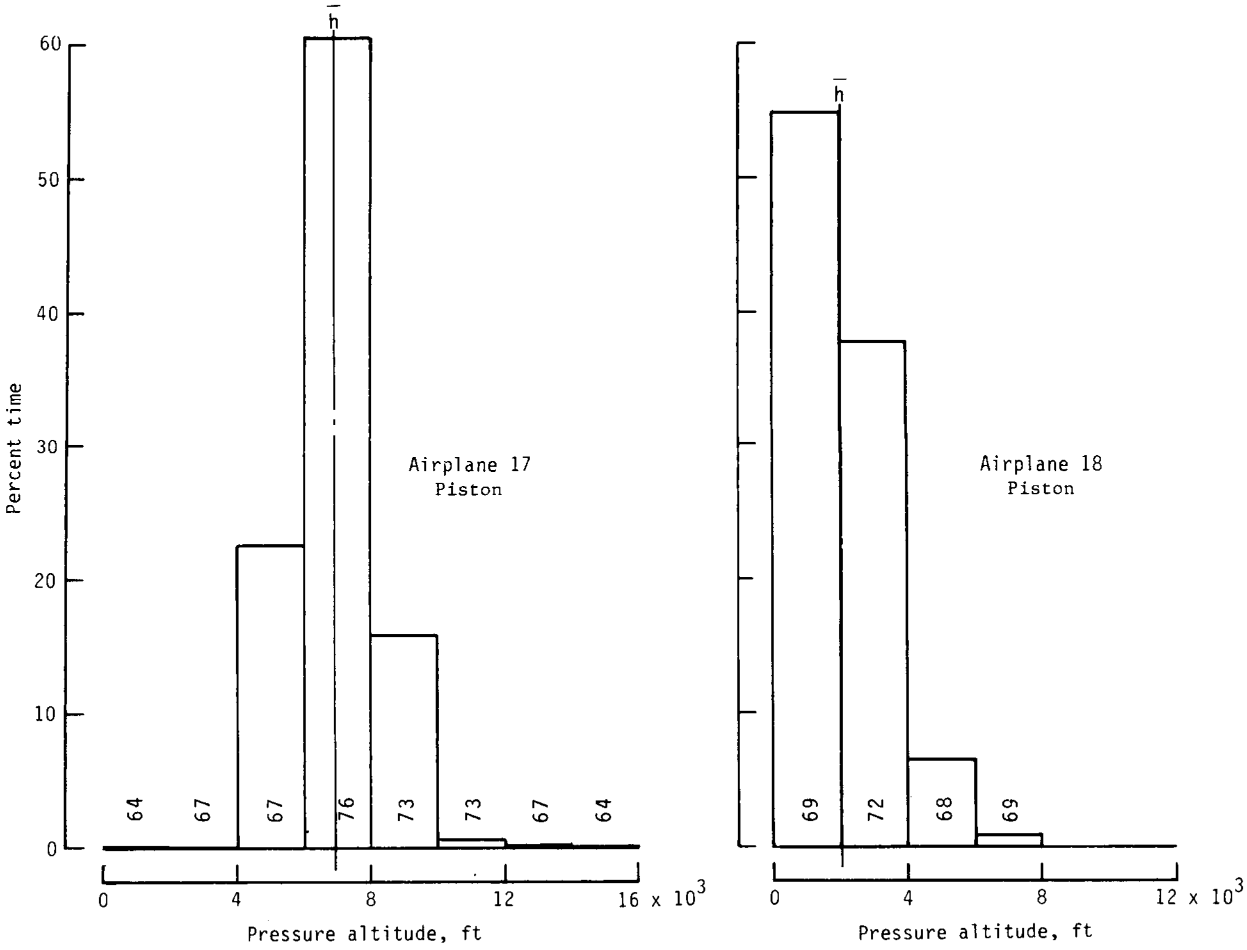
(d) Continued.

Figure 8.- Continued.



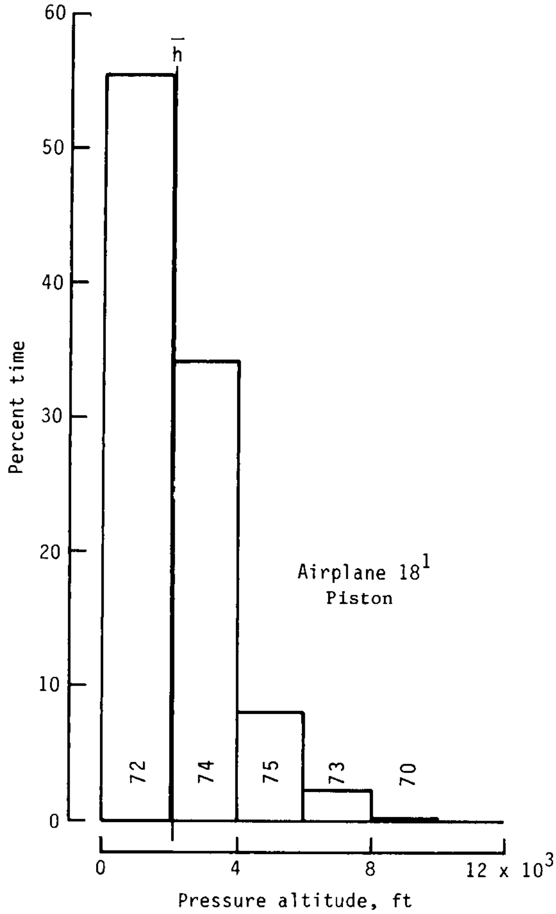
(d) Continued.

Figure 8.- Continued.



(d) Continued.

Figure 8.- Continued.



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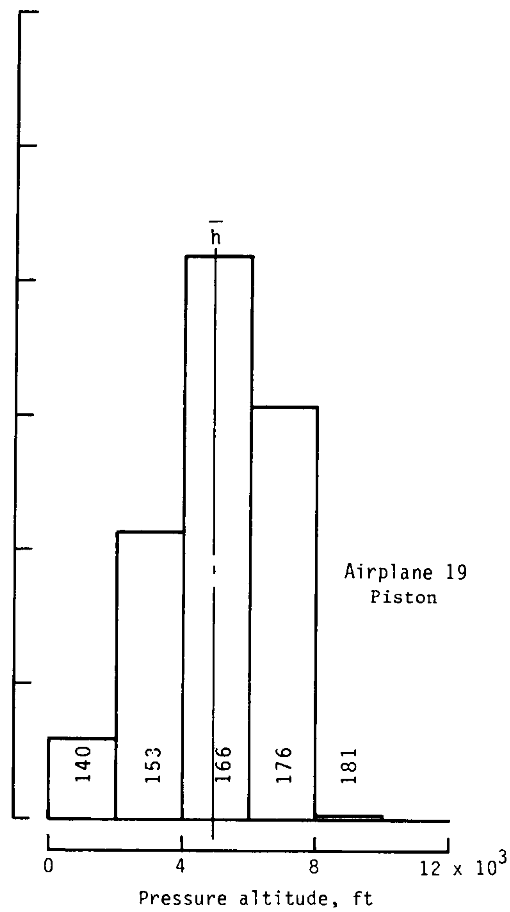

(e) Commercial survey operations.

Figure 8.- Continued.

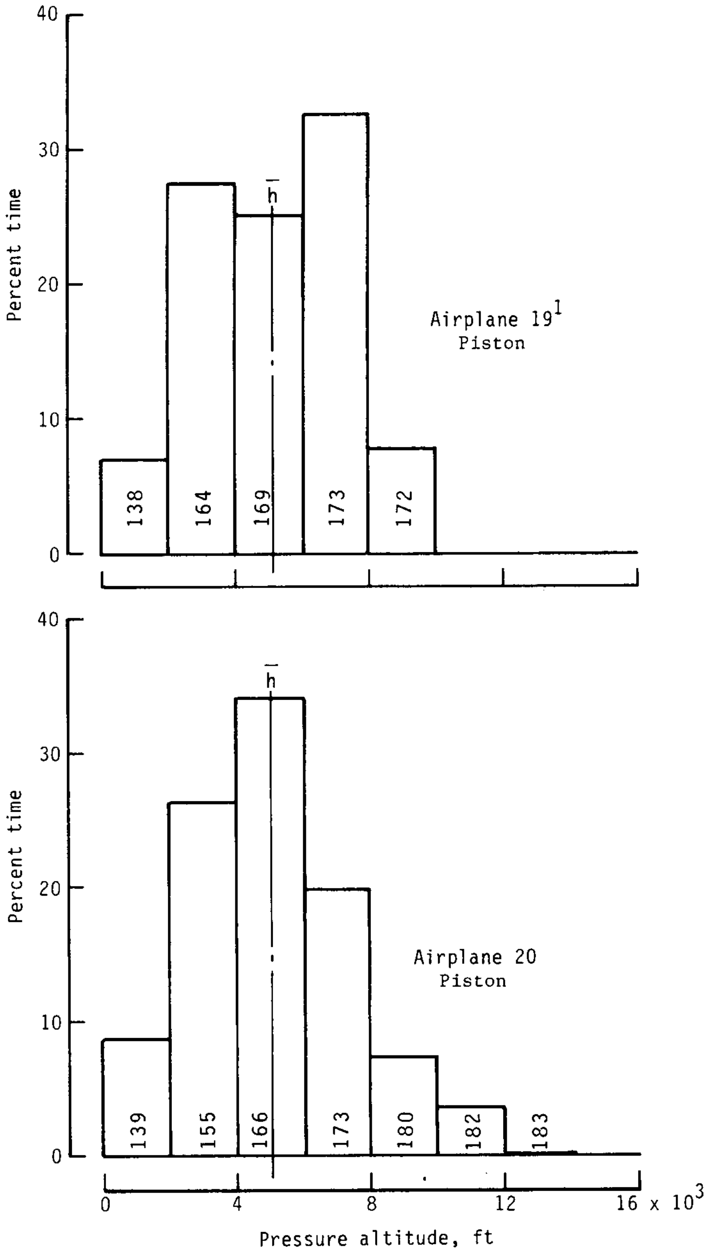

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Figure 8.- Continued.

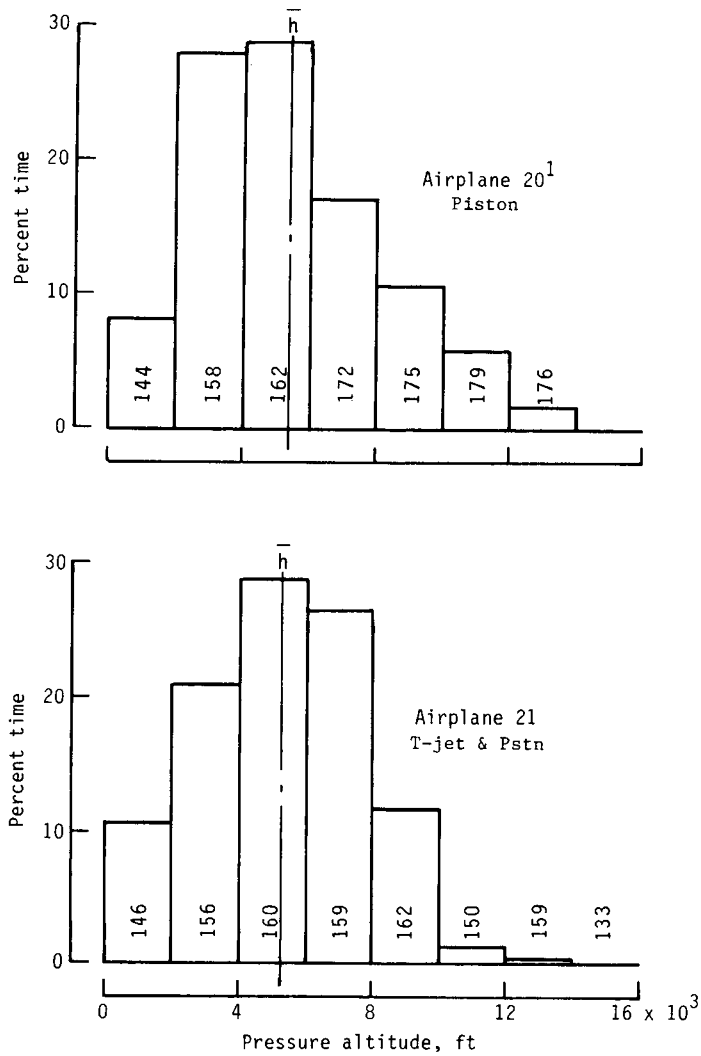

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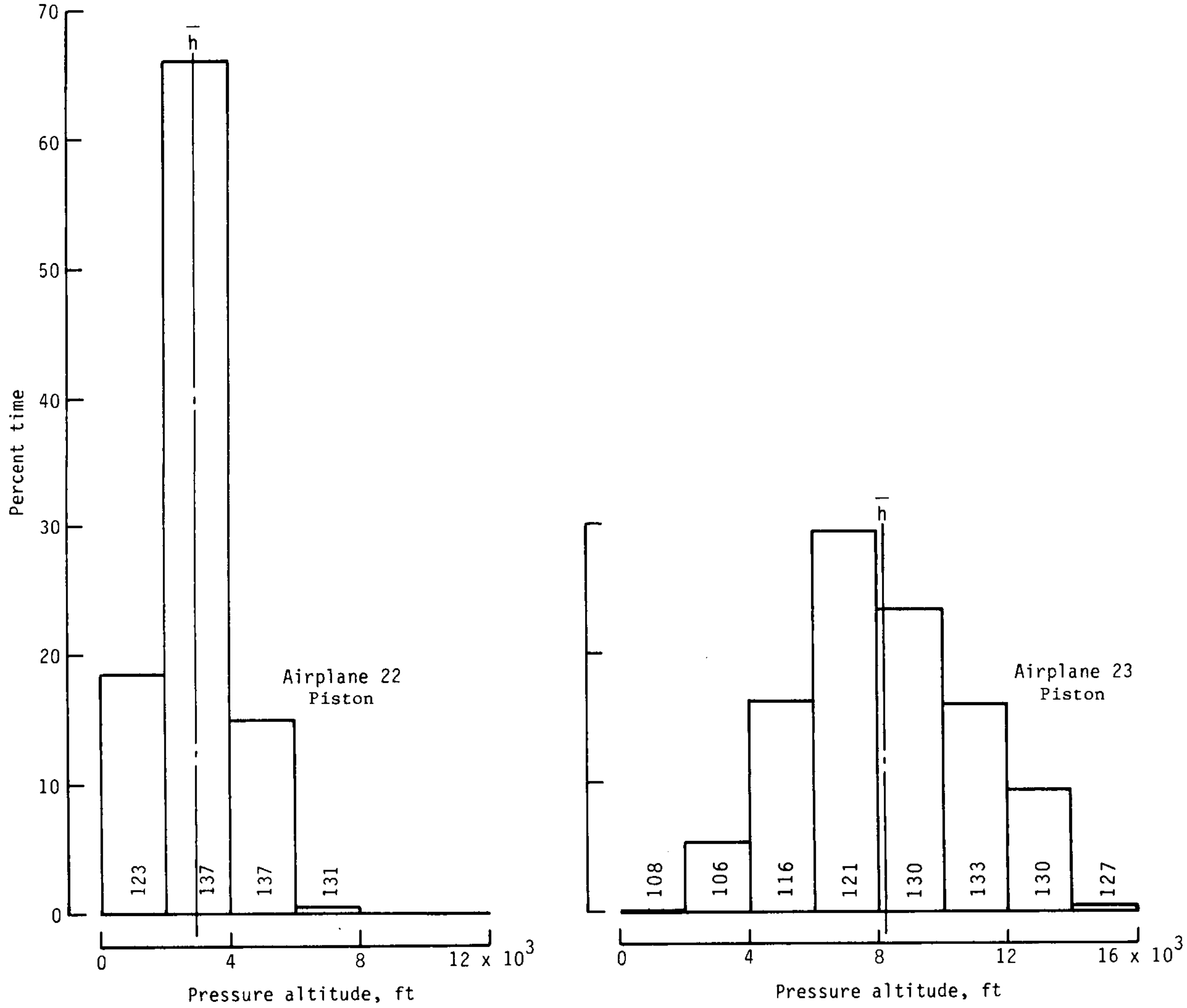
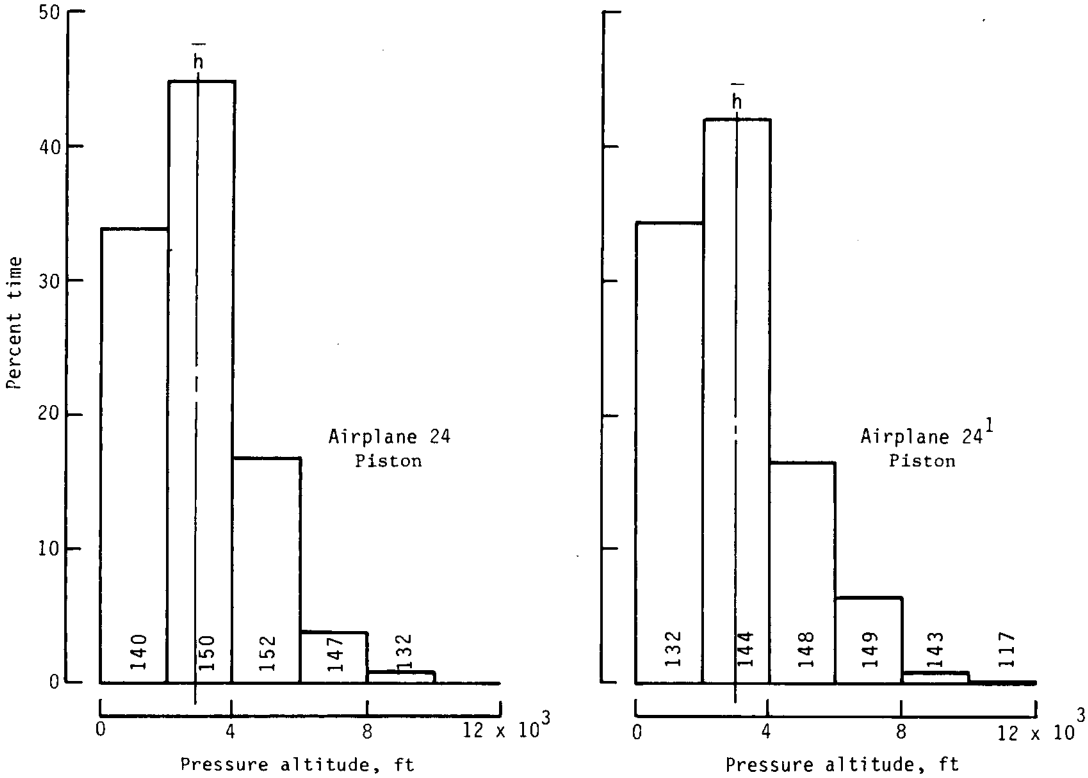
Figure 8.- Continued.



(e) Continued.

Figure 8.- Continued.



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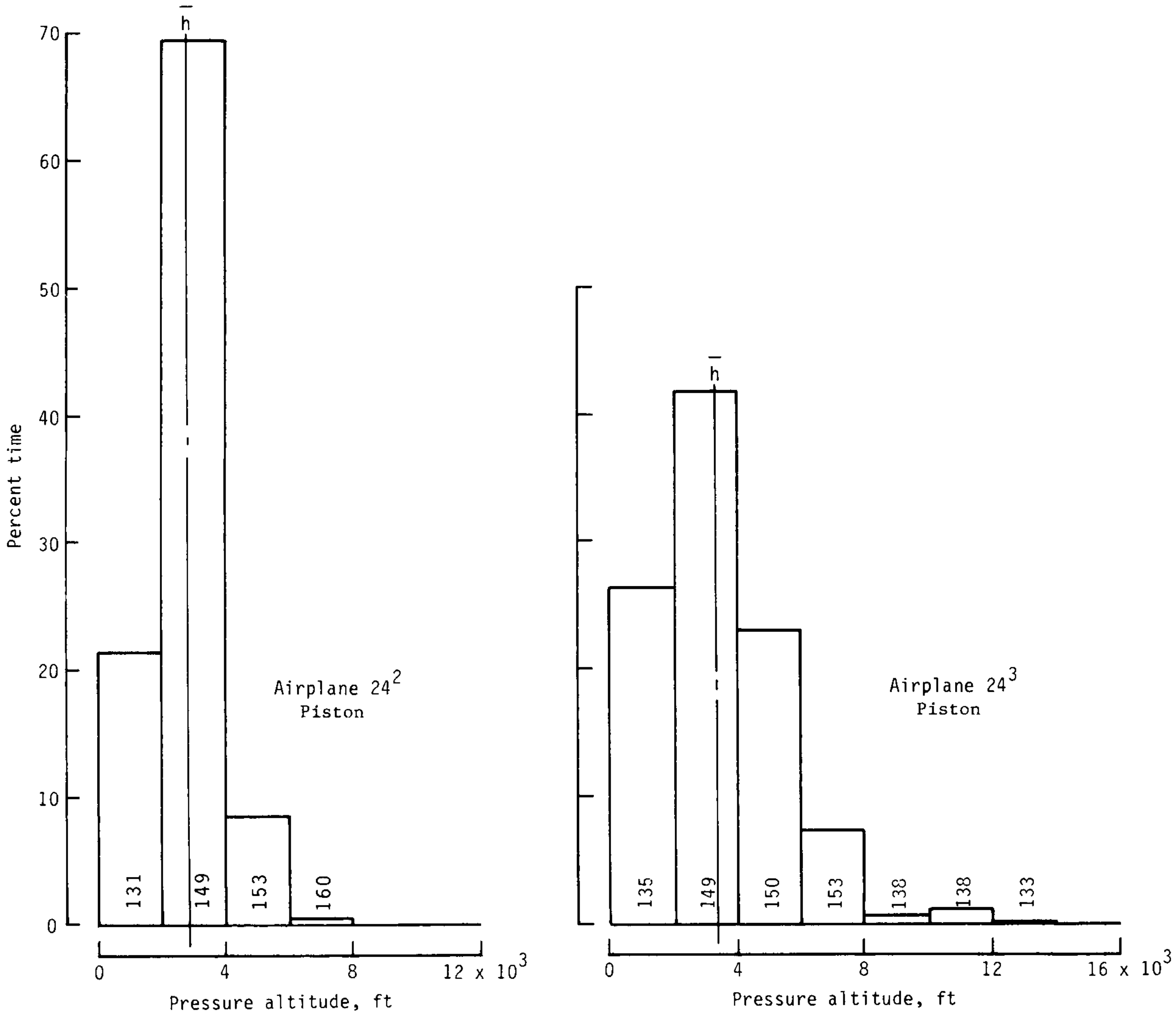

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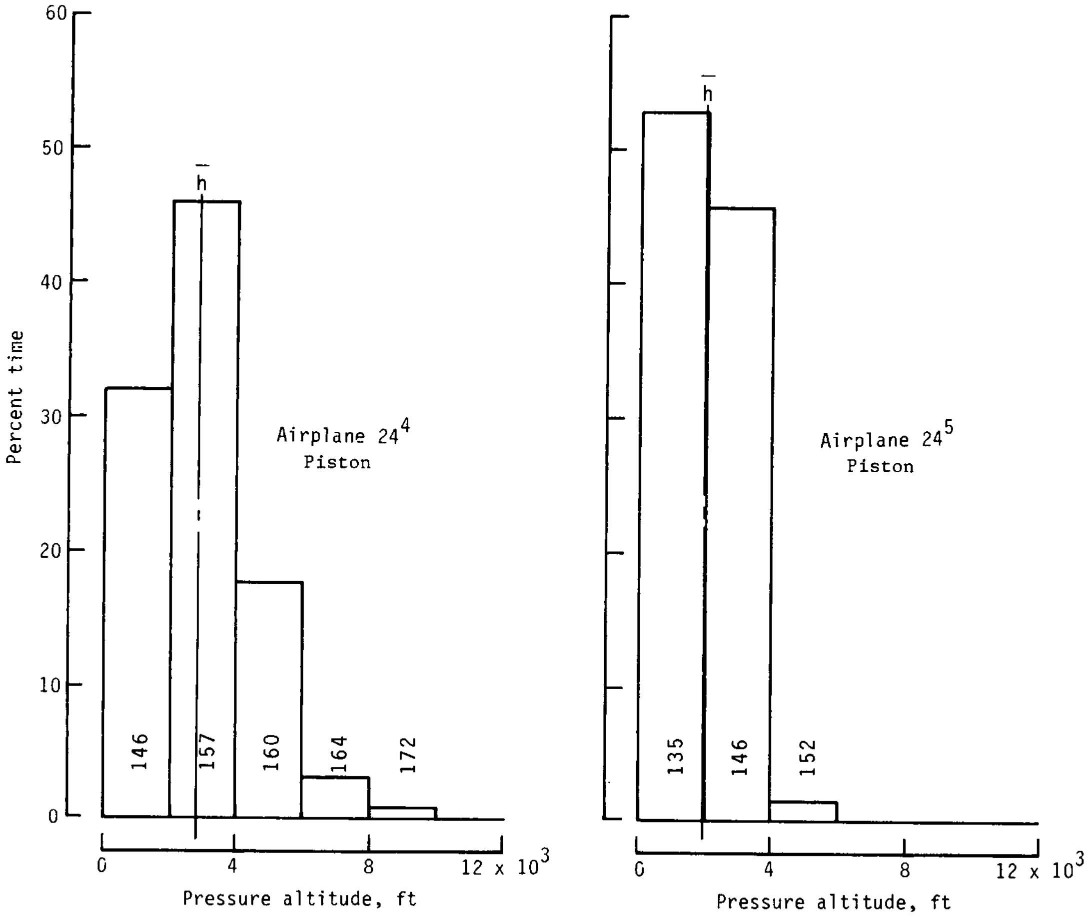

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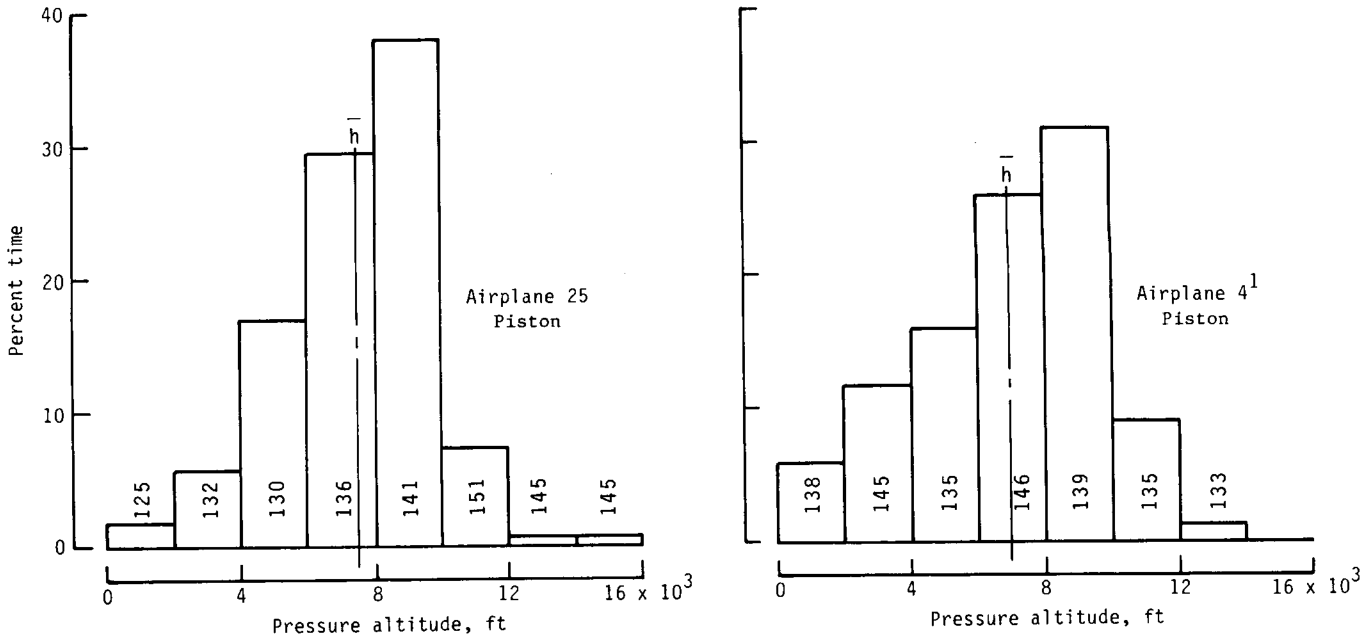
Figure 8.- Continued.



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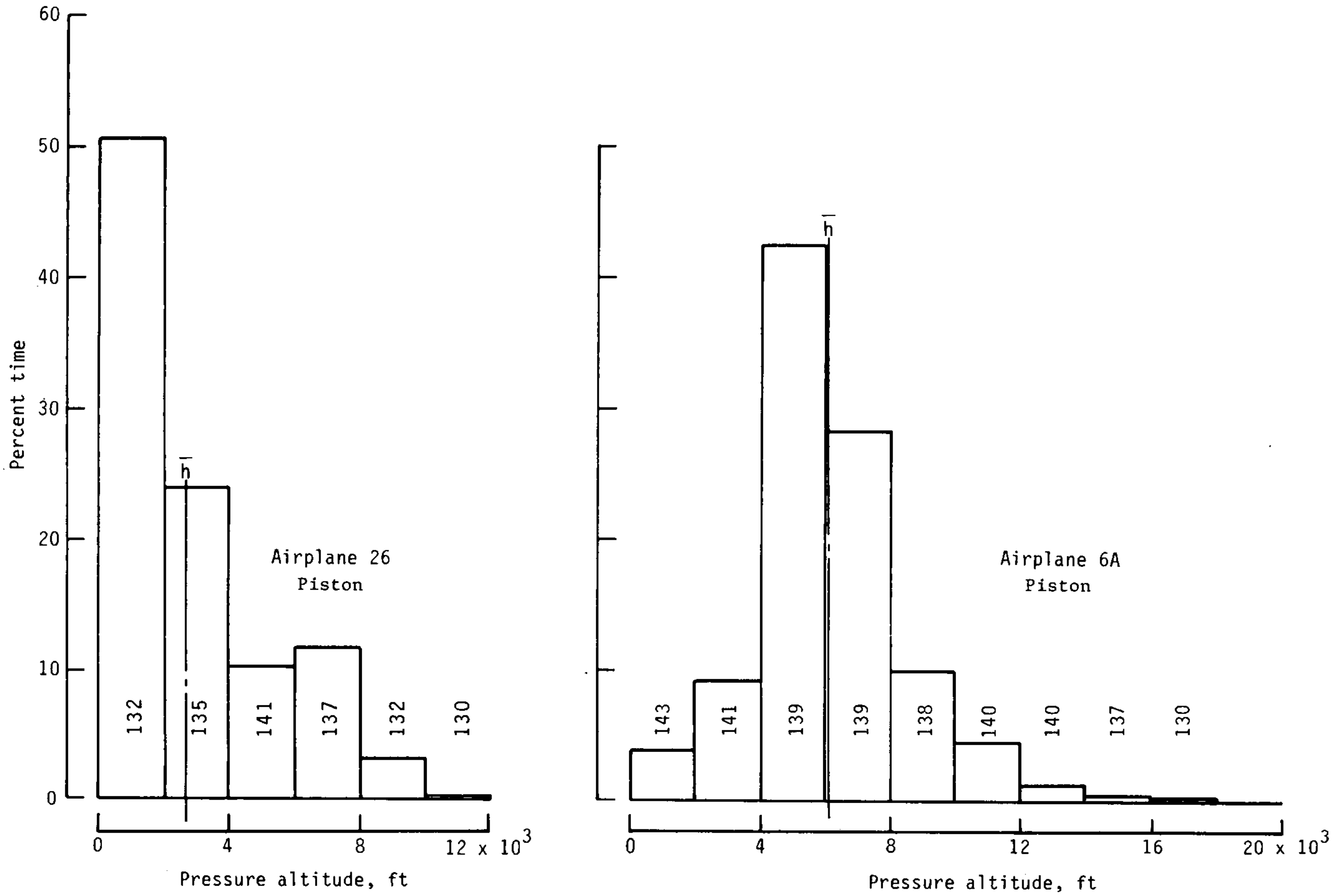

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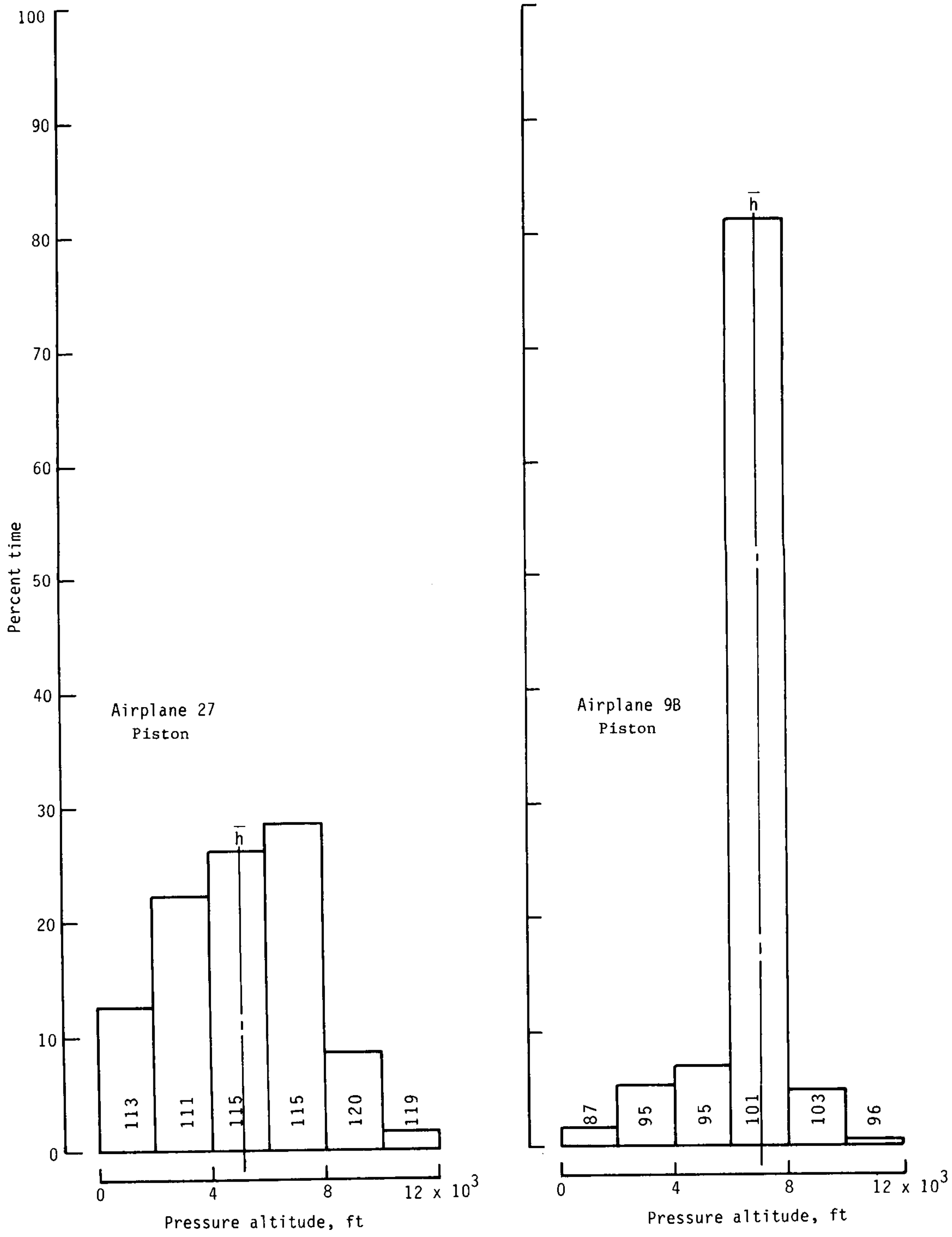

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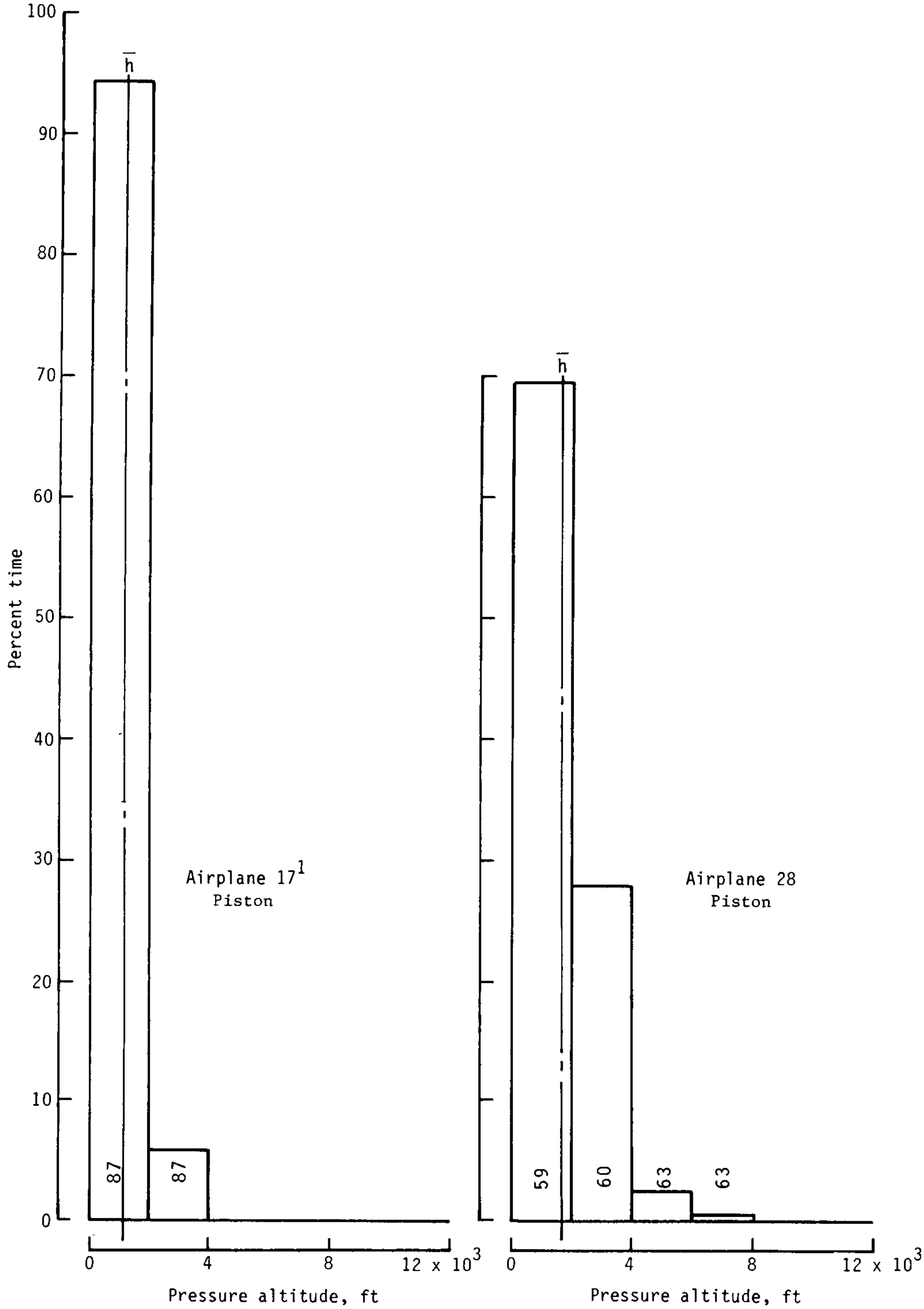
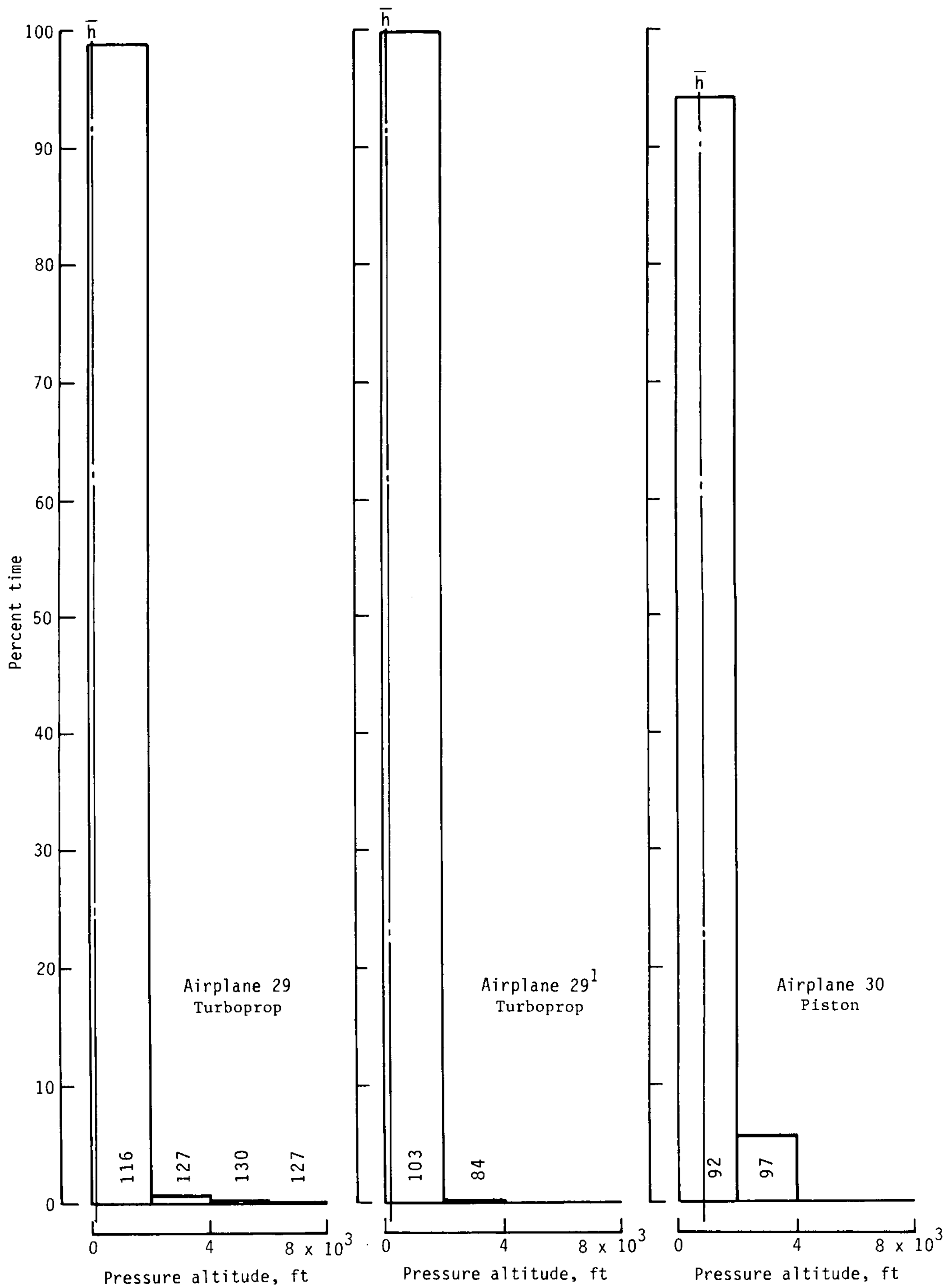


(e) Concluded.

Figure 8.- Continued.



(f) Aerial application operations.

Figure 8.- Continued.

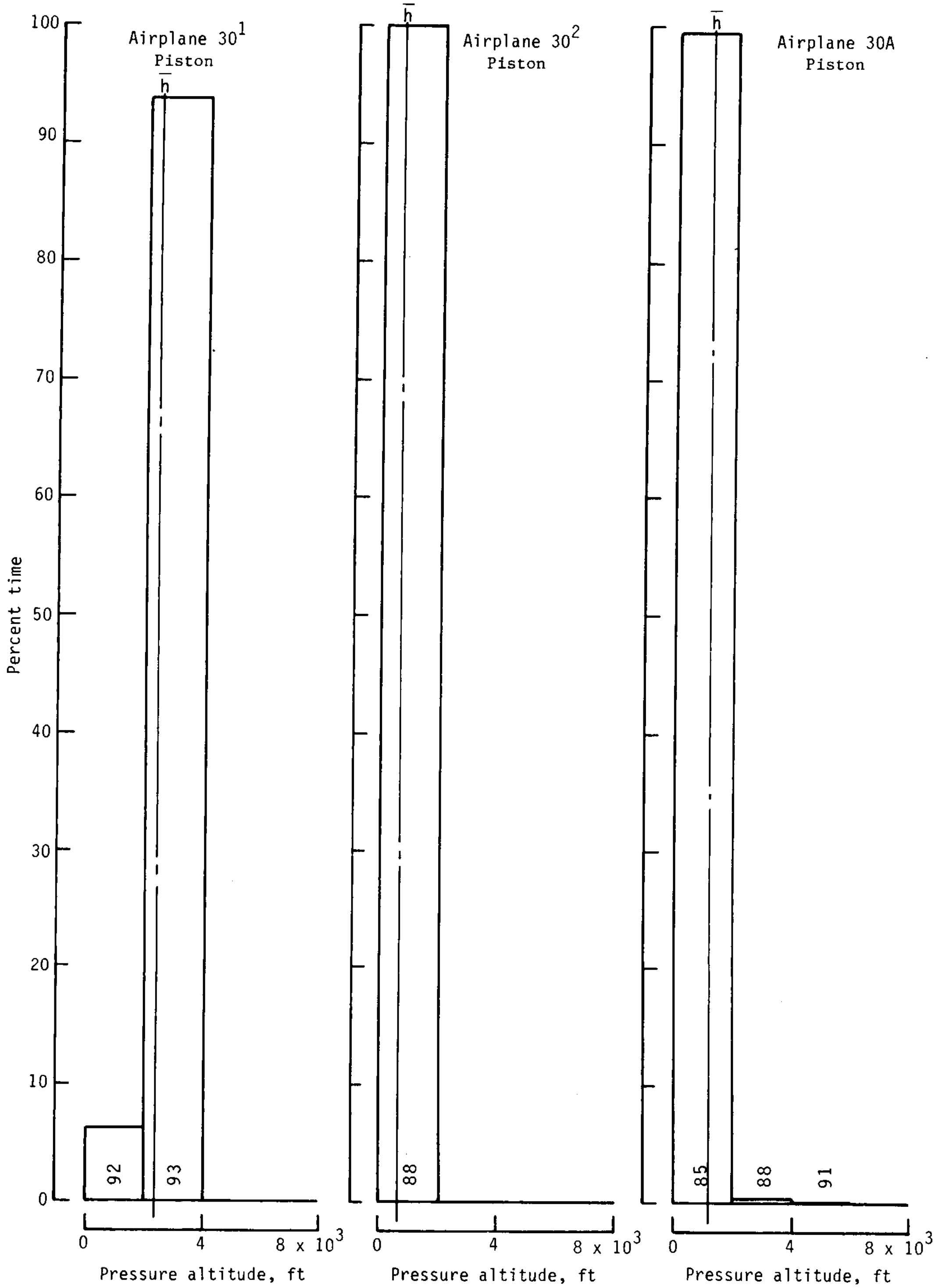


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Figure 8.- Continued.

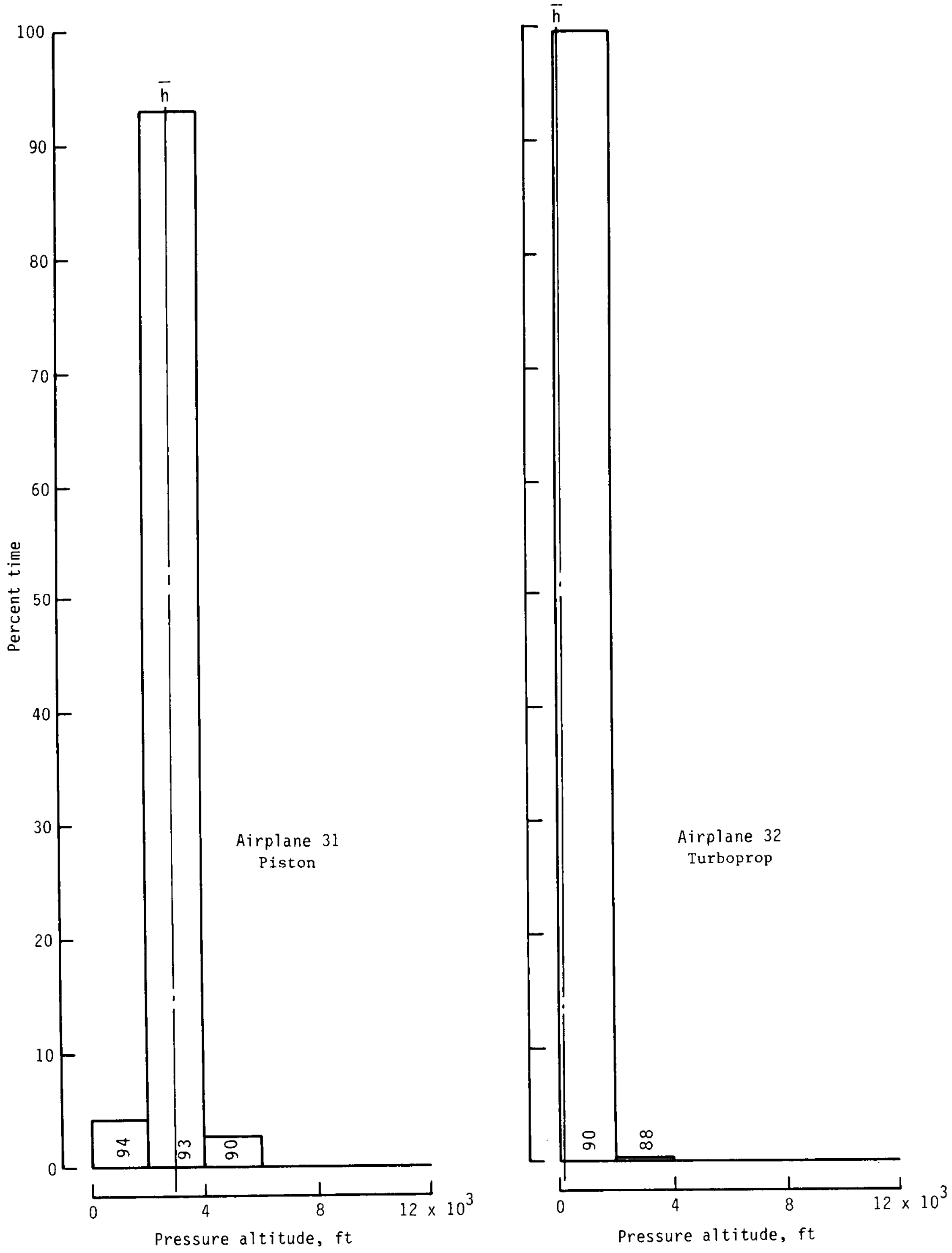

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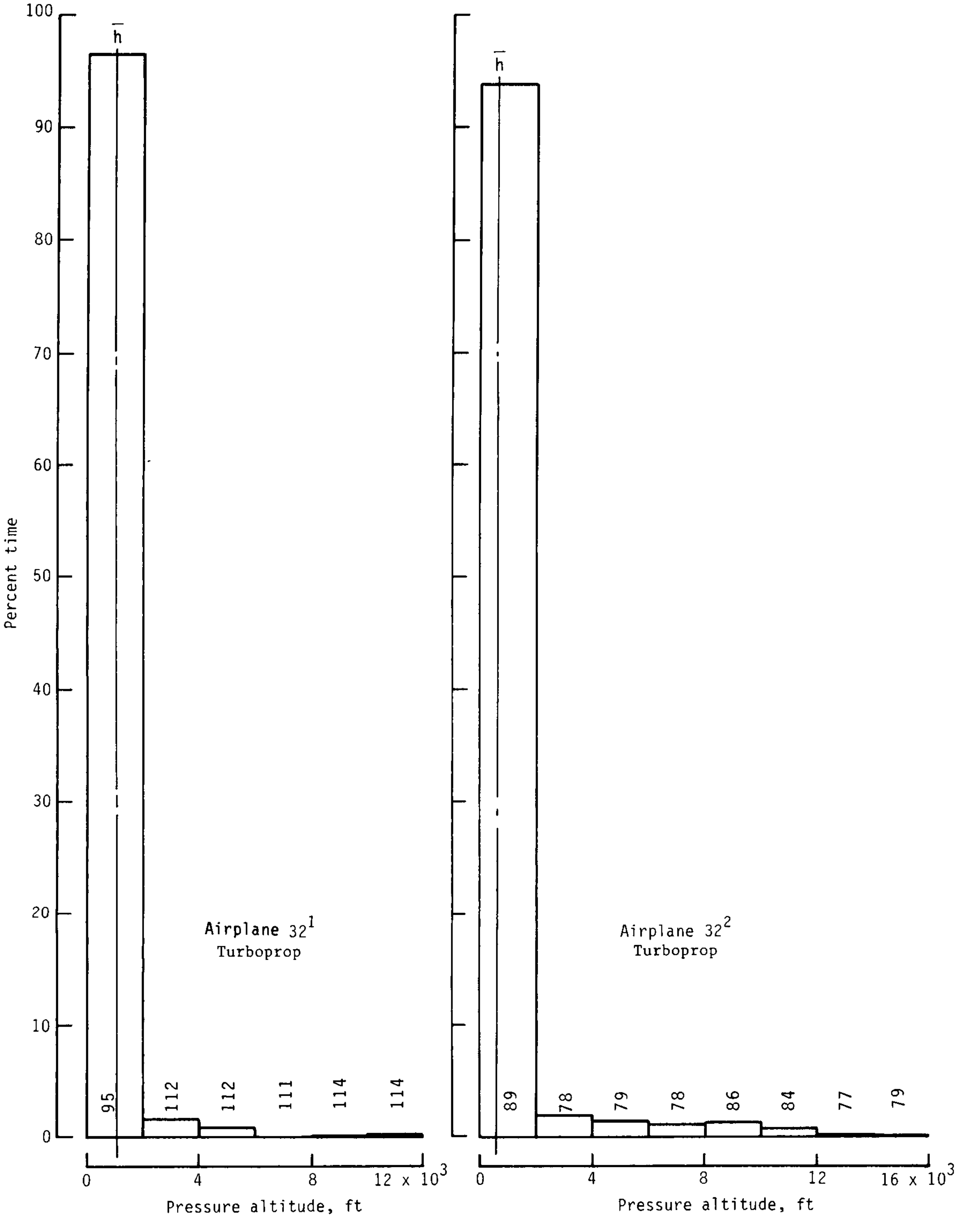
Figure 8.- Continued.



(f) Continued.

Figure 8.- Continued.

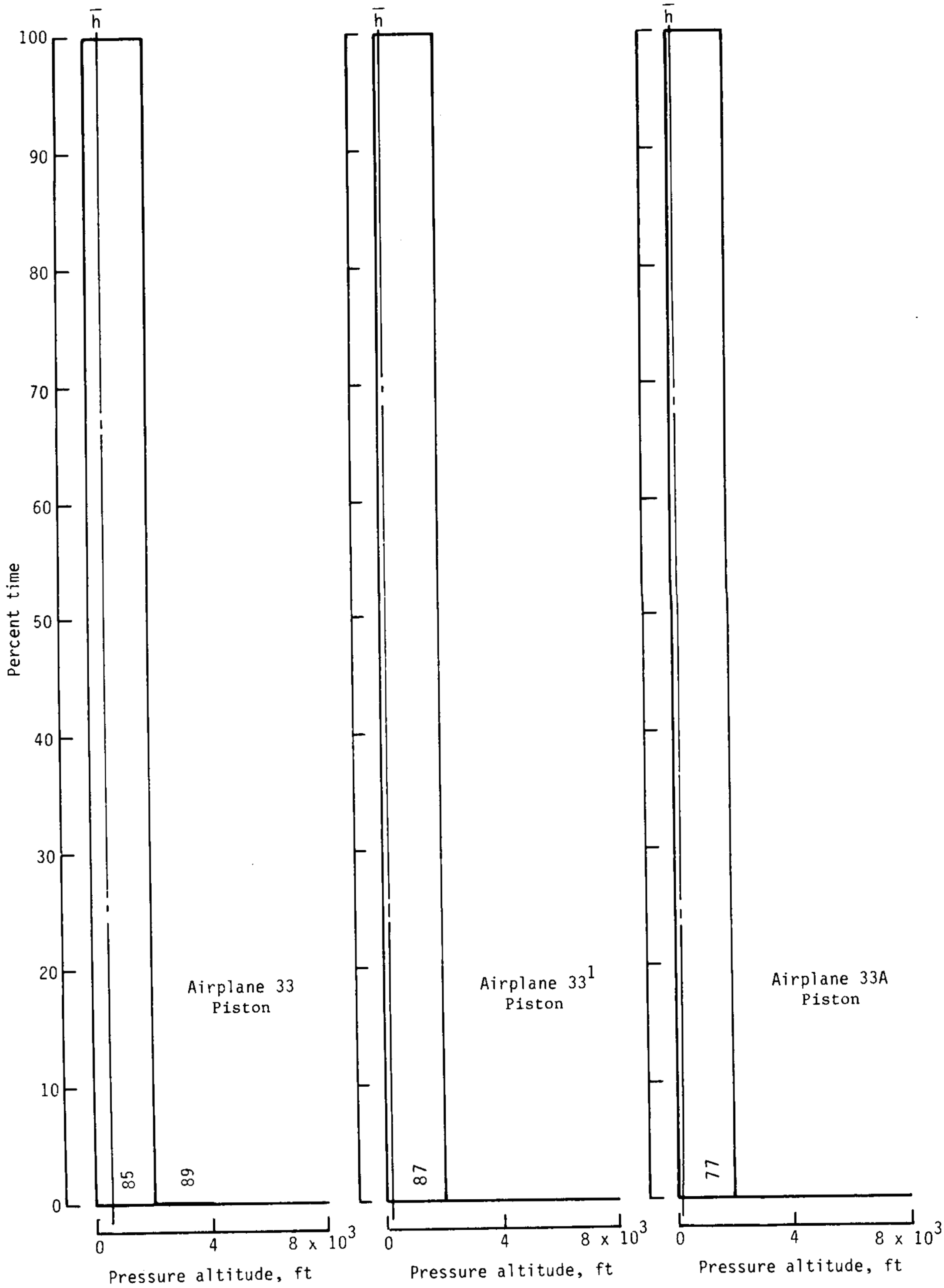


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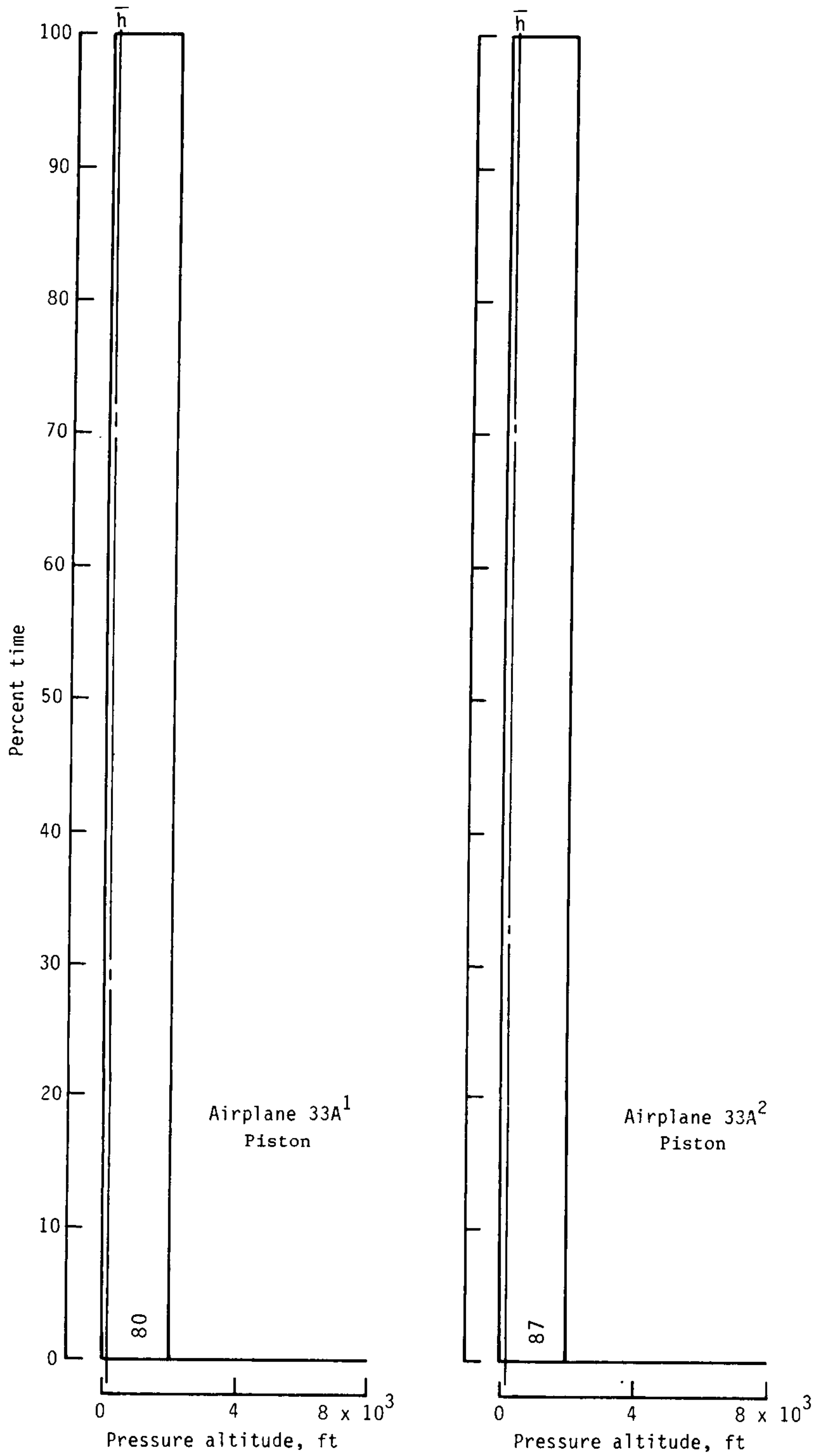
Figure 8.- Continued.



(f) Continued.

Figure 8.- Continued.

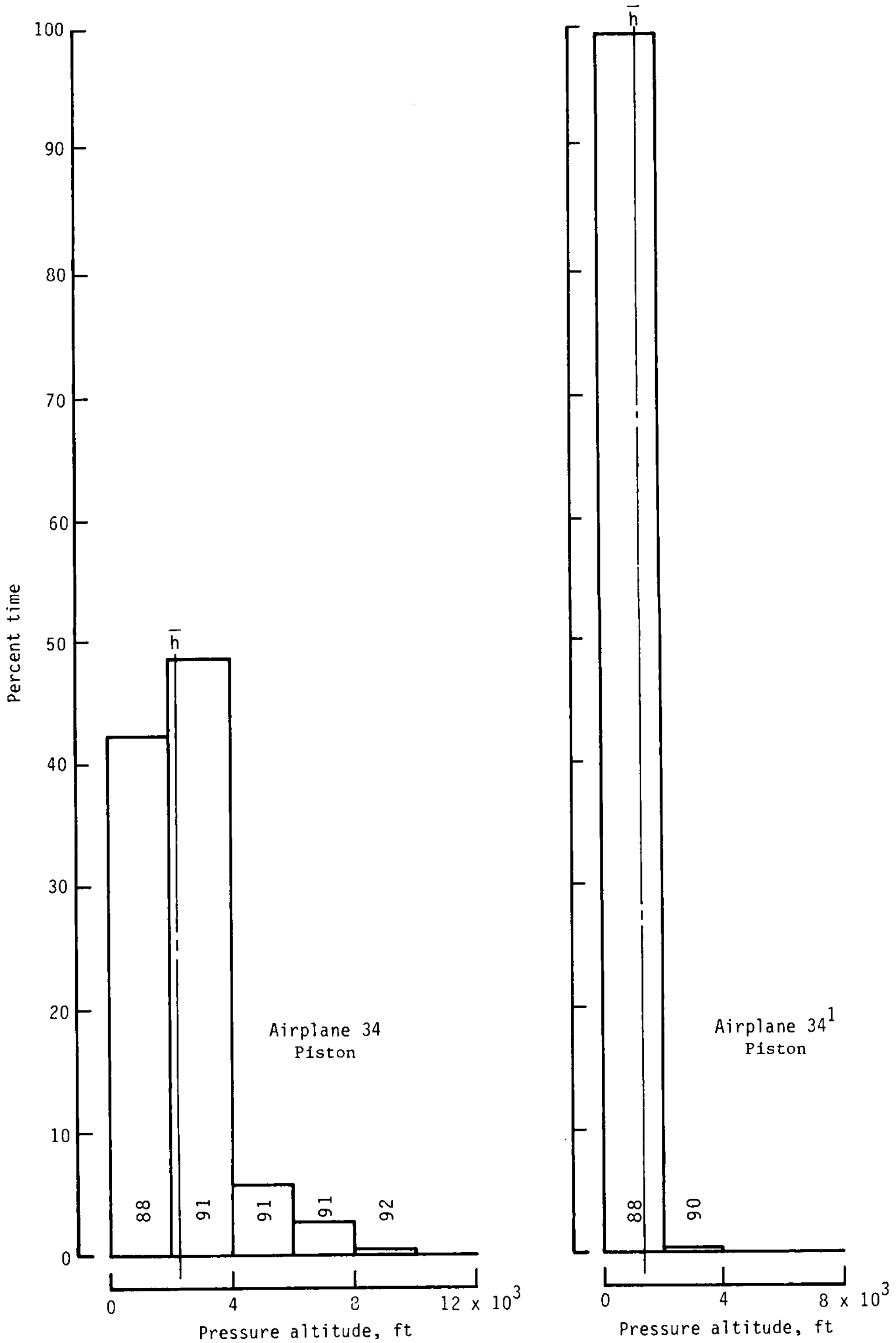


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Figure 8.- Continued.

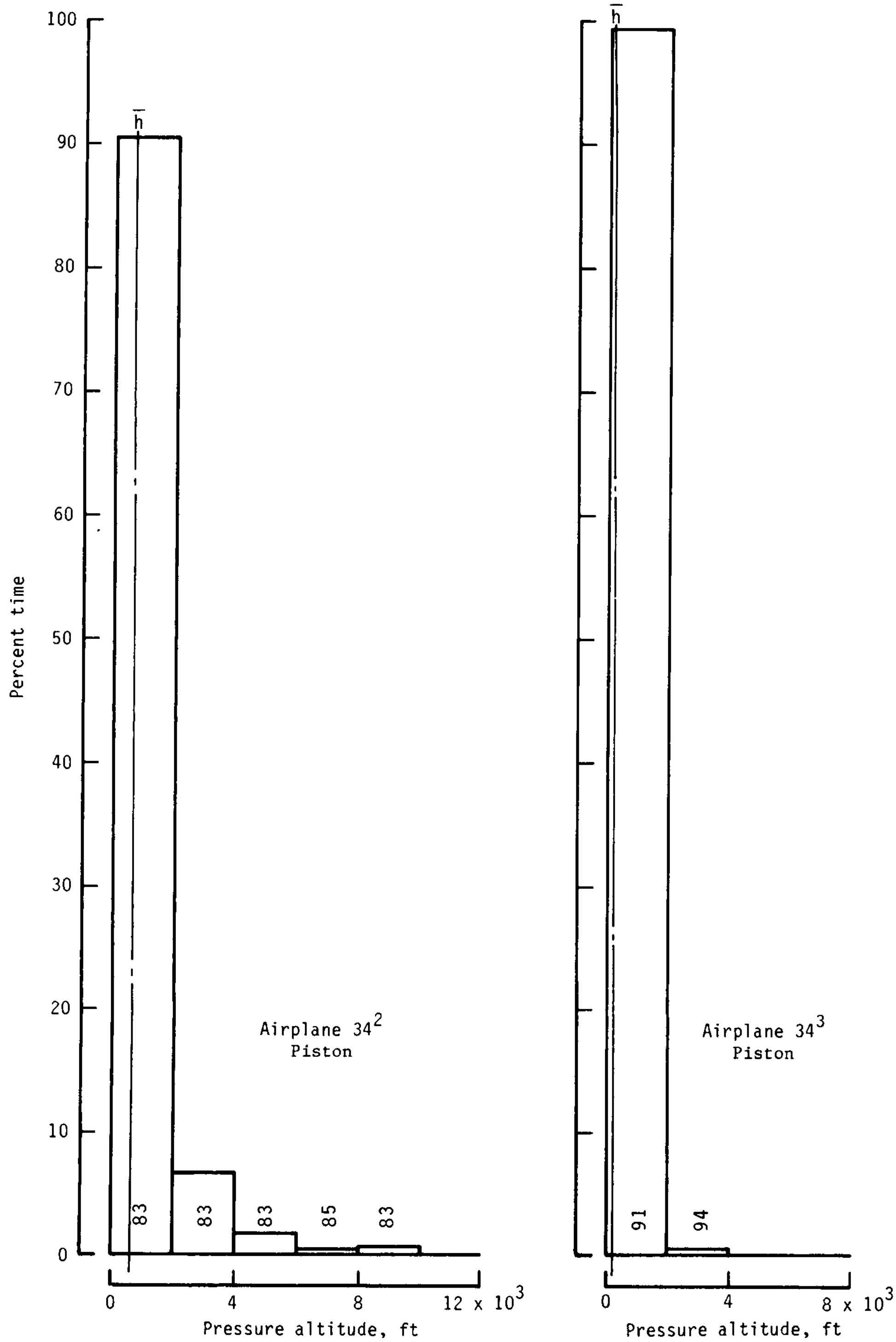

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Figure 8.- Continued.

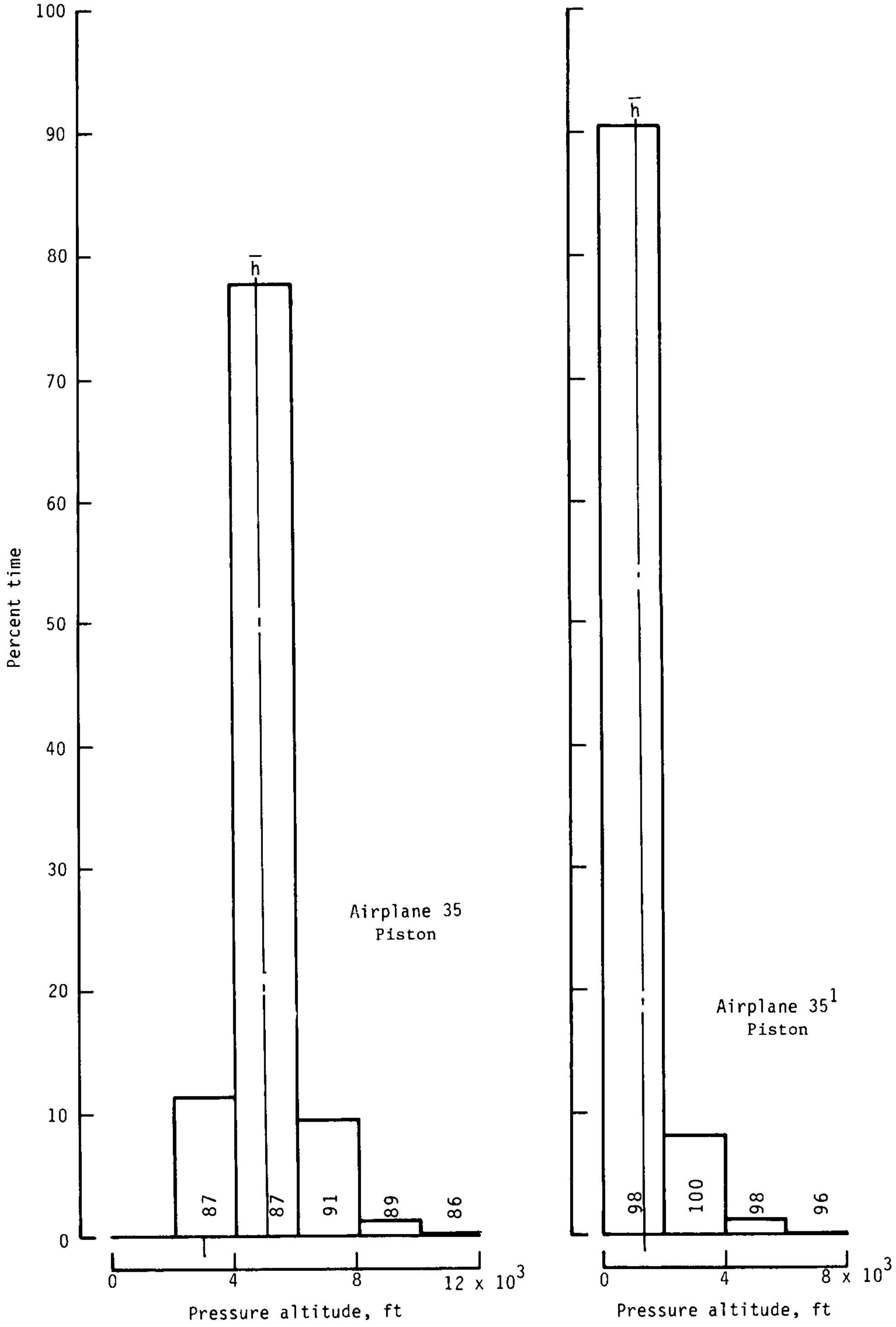

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Figure 8.- Continued.

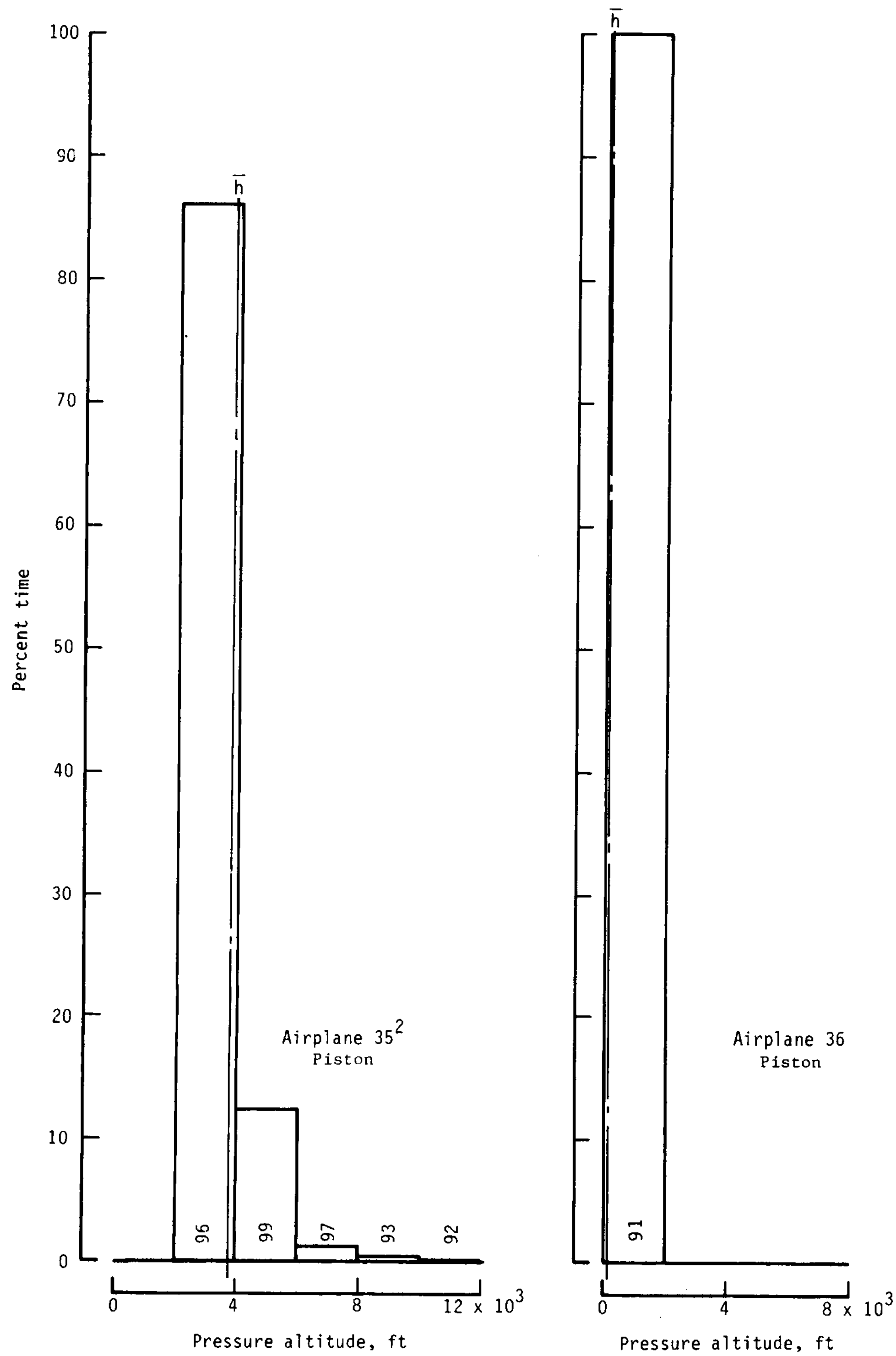

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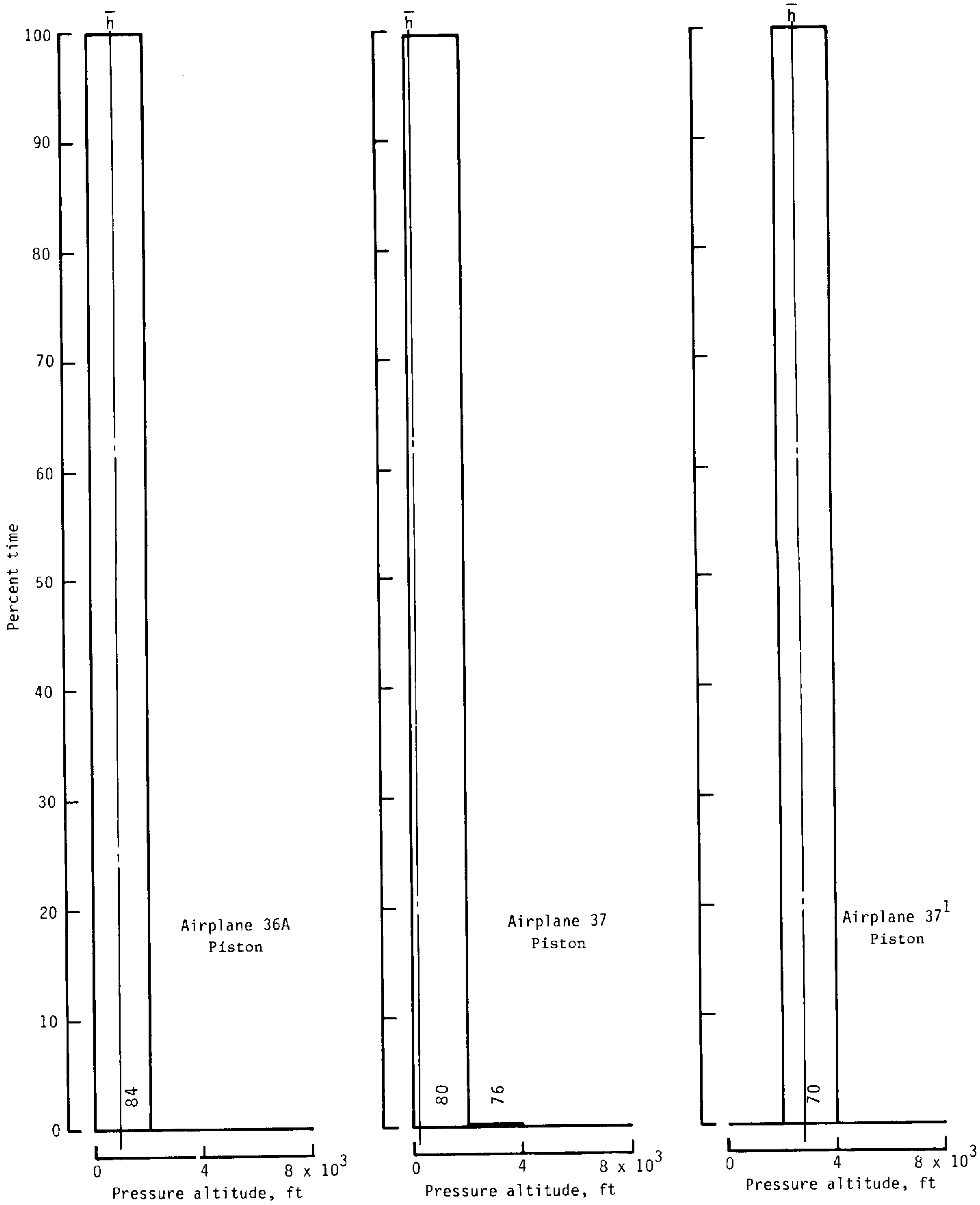
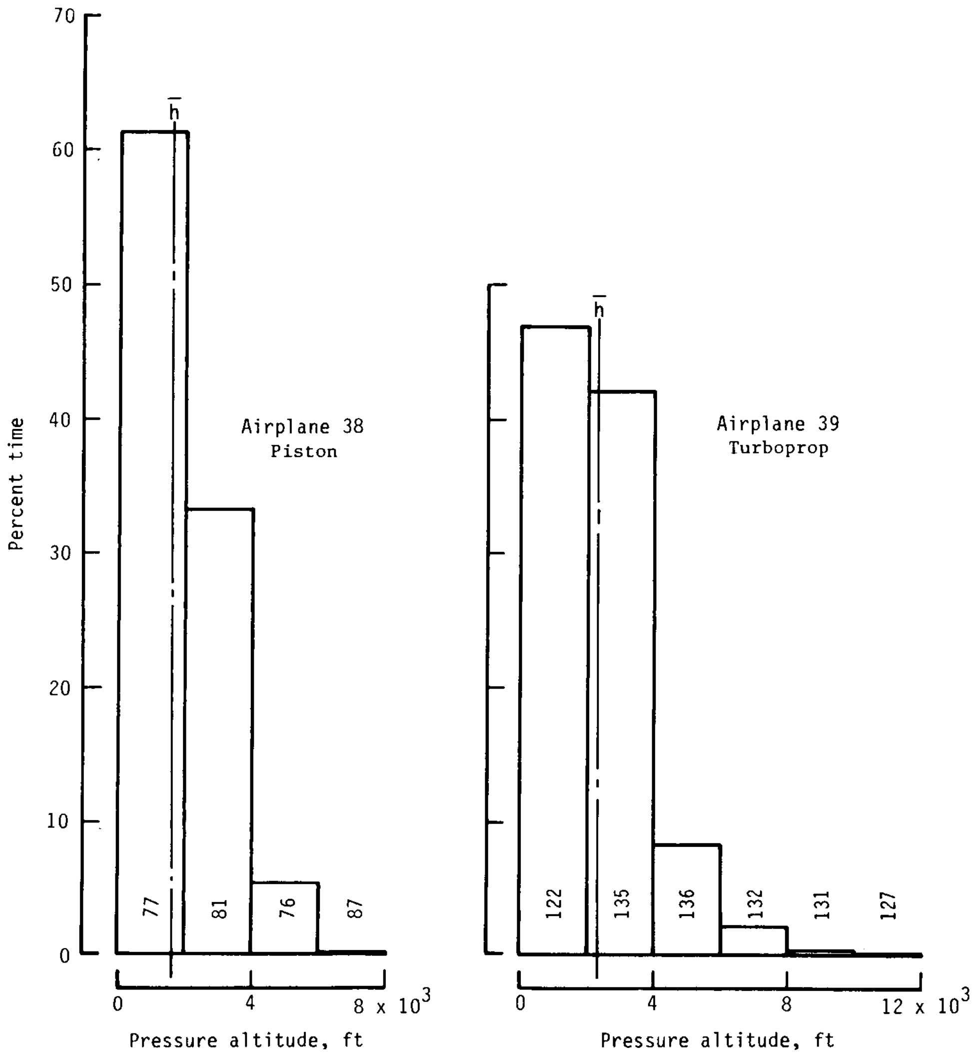
Figure 8.- Continued.



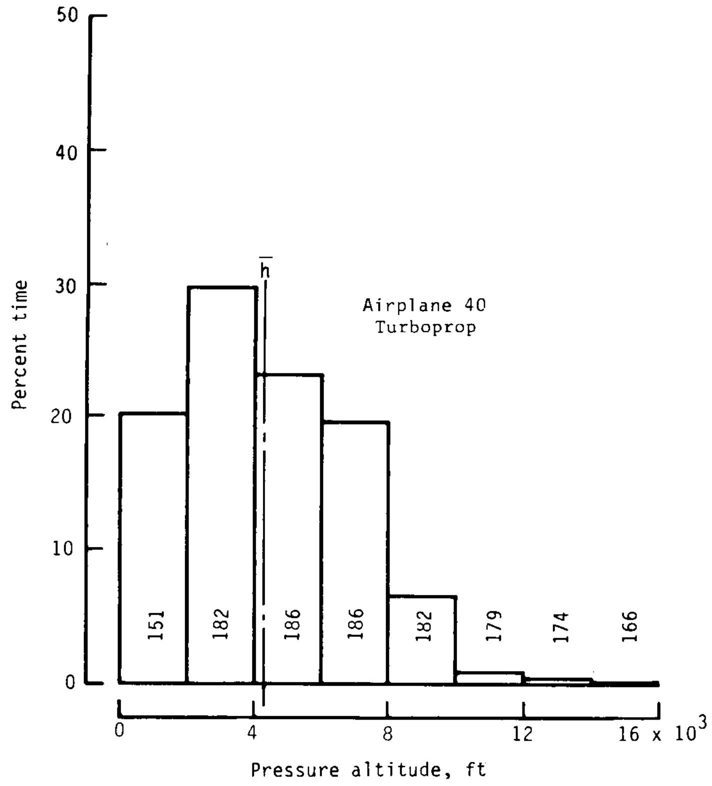
(f) Concluded.

Figure 8.- Continued.

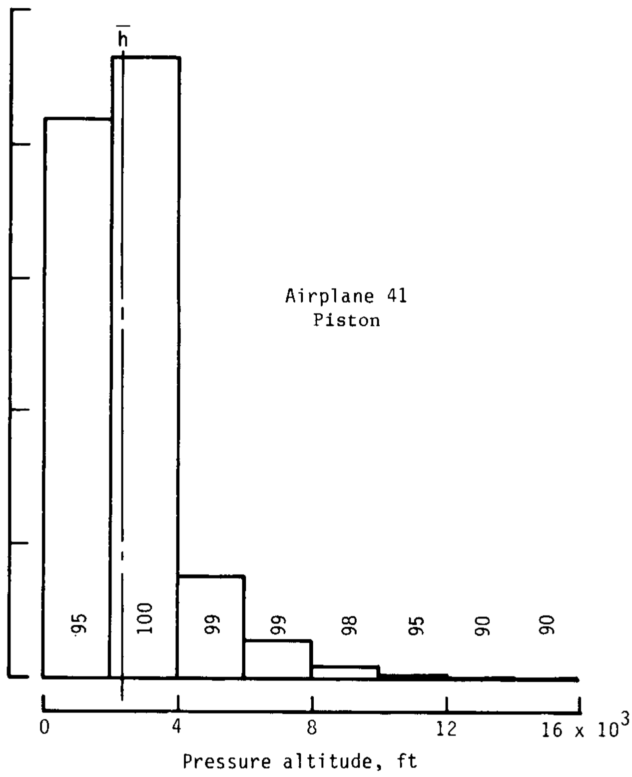


(g) Aerobatic operations. (h) Commuter operations.

Figure 8.- Continued.



(h) Concluded.



(i) Float operations.

Figure 8.- Concluded.

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16. Abstract

Flight duration, airspeed, and altitude information obtained from NASA VGH recorders are presented for each of 95 general aviation airplanes flown in twin- and single-engine executive, personal, instructional, commercial survey, aerial application, aerobatic, commuter, and float operations. These data complement normal acceleration data obtained from the same airplanes and reported in NASA TM-84660, and together they provide a data base for the design and analysis of general aviation airplane operations.

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